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THESIS

THE USE OF SIMULATORS IN RULES OF THE ROAD TRAINING

by

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December 2013

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The use of simulation technology, in conjunction with instructor led rules of the road (RoR) lectures, is in the infancy stages of curriculum development in maritime institutions. As a result, there are few studies that analyze whether using simulators will increase a student's ability to apply maritime rules that prevent collisions at sea in a simulation based scenario. This study hypothesized that students who used a Full Mission Bridge simulator and received lectures would achieve higher scores on a RoR test than those who did not receive simulator training but did receive lectures. Utilizing 27 active duty participants that used a simulator and 341 examinees who did not use a simulator at Surface Warfare Officer School Newport, our results showed statistically significant data that students who used the simulator performed better on a RoR test than those who did not. This study recommends that incorporating simulation technology into curricula that have traditionally been only instructed in a classroom environment is beneficial, especially in learning RoR. Based on the results of this study, there is a need for incorporating simulation technology in traditionally instructed courses, where applicable, and future studies using simulation technology should be extended to the fleet.

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THE USE OF SIMULATORS IN RULES OF THE ROAD TRAINING

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ABSTRACT

The use of simulation technology, in conjunction with instructor led rules of the road (RoR) lectures, is in the infancy stages of curriculum development in maritime institutions. As a result, there are few studies that analyze whether using simulators will increase a student's ability to apply maritime rules that prevent collisions at sea in a simulation based scenario. This study hypothesized that students who used a Full Mission Bridge simulator and received lectures would achieve higher scores on a RoR test than those who did not receive simulator training but did receive lectures. Utilizing 27 active duty participants that used a simulator and 341 examinees who did not use a simulator at Surface Warfare Officer School Newport, our results showed statistically significant data that students who used the simulator performed better on a RoR test than those who did not. This study recommends that incorporating simulation technology into curricula that have traditionally been only instructed in a classroom environment is beneficial, especially in learning RoR. Based on the results of this study, there is a need for incorporating simulation technology in traditionally instructed courses, where applicable, and future studies using simulation technology should be extended to the fleet.

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LIST OF ACRONYMS AND ABBREVIATIONS

72 COLREGS	International Regulations for Prevention of Collisions at Sea, 1972
ASAT	Advance Ship-handling and Tactics
CDR	commander
CG	guided-missile cruiser
CIC	Combat Information Center
COMNAVSURFORLANT	Commander Naval Surface Force, U.S. Atlantic Fleet
COMNAVSURFORPAC	Commander Naval Surface Force, U.S. Pacific Fleet
COVE	Conning Officer Virtual Environment
CPA	closet point of approach
CSC	Computer Science Corporation
DDG	guided missile destroyer
DH	department head
DIVTACS	divisional tactics
FCA	fleet concentration area
FFG	guided missile frigate
FMB	full mission bridge
HMD	head-mounted display
LCS	littoral combat ship
LT	lieutenant
LPD	amphibious transport dock
MCM	mine countermeasures
NPS	Naval Postgraduate School
NROTC	Naval Reserve Officer Training Corps
NSST	navigation seamanship ship-handling training
NUC	not under command
OOD	officer of the deck
OPNAV	Office of the Chief of Naval Operations

OSS	optical sight system
PCO	prospective commanding officer
RMD	restricted in ability to maneuver
RoR	rules of the road
SWO	surface warfare officer
SWOS	Surface Warfare Officer School
TYCOM	type commander
UNREP	underway replenishment
USCG	United States Coast Guard
USN	United States Navy
USNA	United States Naval Academy
VBS2	Virtual Battlespace 2
VHF	very high frequency
VMS	voyage management system
VShip	virtual ship

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Aditya Wahyue said, “The main cause of failure is the habit of stopping before completion” (2013). There were many days while writing this thesis that I wanted to stop, but with a support system of family, friends, professors, and the Navy, stopping was never an option. When I wanted to stop, there was always someone telling me to keep going, whether it was my wife, son, or several United States Navy captains. If I had to list everyone that helped, my acknowledgments could be a chapter by itself. So in case I miss anyone, do not feel offended, because I appreciated your help as well.

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I. INTRODUCTION

A. PROBLEM STATEMENT

Similar to roadways and airways, the sea is governed by rules and laws that assist in preventing collisions. These rules and laws can be summarized as the Rules of the Road (RoR), whether that is on the sea, land, or air. In the instance of the ocean, all vessels abide by one of the two main set of rules. In international waters, ships follow the International Regulations for Preventing Collisions at Sea 1972 (72 COLREGS). Additionally, each nation has its own rules for ships in its interior waterways. For example, in the U.S., these are the Inland Navigation Rules. Even though these rules are similar to one another, it is critical that those who operate any vessel at sea not only know these rules but also understand how to apply them.

While attending Naval War College in 1960, Captain W. B. Hayler stated, “a collision at sea can ruin your entire day.” Never has this statement been more paramount than for the men and women serving in today’s world of transporting goods and nations maintaining or attempting to establish sea power. Figure 1 shows a 35.34 percent increase in the number of ships at sea from 1985 to 2010 as reported in the Lloyds Register Fairplay, *World Fleet Statistics 1900 to 2010* (Sampson, Ellis, Gould, Tang, Turgo, & Zhao, 2012). Despite this rise in maritime transportation, total losses at sea have decreased over that time span; however, these total losses still can cost up to millions of dollars in damage and the loss of irreplaceable role models in those they may leave dead (Sampson et al, 2012).

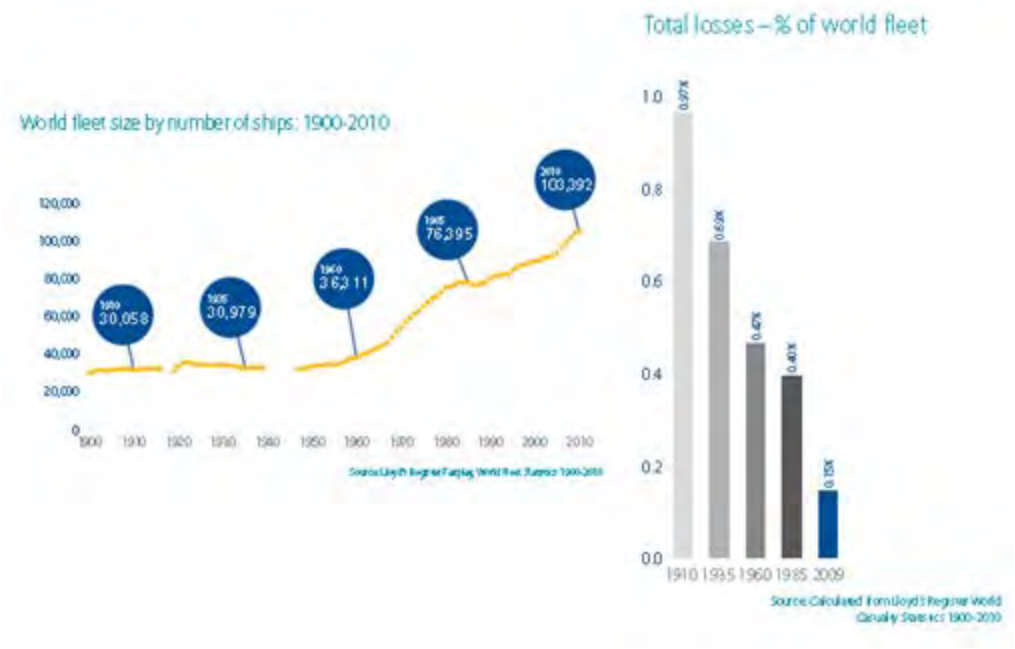

Figure 1. World fleet size by number of ships and total losses (collision, contact, fire/explosion, foundering, wrecked/stranded, hull/machinery, missing and other) (from Sampson et al., 2012)

It would be easy to assume that an increase in transportation on the sea would lead to an increase in total losses at sea; however, with today's global satellite positioning systems, communication circuits, radars, and other maritime technology equipment the frequency of total losses has decreased. The fleet has some of the most advanced equipment in the world to train the personnel who operate its ships to prevent such losses from occurring. Despite all of our technological advances, we rely on bridge watch teams to safely navigate our ships, because often the RoR require judgment beyond what computers are currently capable of. Until that technological advancement is achieved, bridge watch teams must safely navigate the ship; otherwise, a ship can be placed in the most catastrophic event not involving war, risk of collision at sea.

From the time a midshipman or officer candidate is designated to be a surface warfare officer (SWO) through the rank of captain, SWOs will receive over a hundred hours of simulator training to demonstrate they have the ability to safely navigate the ship that they are reporting to or are currently serving on.

The United States Naval Academy (USNA), Naval Reserve Officers Training Corps (NROTC), Surface Warfare Officer School Newport (SWOS), fleet concentration areas (FCA), ships, and pre-commissioning units in Bath, Maine and Pascagoula, Mississippi utilize multi-million dollar ship-handling simulators to teach or maintain ship-handling skills that primarily focus on: pier work, transiting in and out of homeport, underway replenishment (UNREP), man overboard, and division tactics (DIVTACS). The focus of avoiding collision with another vessel in accordance with the RoR is not the primary focus of these ship-handling simulators until the officer is in department head (DH) school or in the command-at-sea pipeline at SWOS. For example, in the ASAT curriculum, only 31 percent of simulator time is focused towards navigating in waters where there will be several commercial or pleasure craft vessels as shown in Table 1. The simulator time is usually shared with two to four other students depending upon ship class (e.g., guided-missile frigate [FFG], guided-missile destroyer [DDG], guided-missile cruiser [CG], amphibious transport dock [LPD]) and incorporates two to three hours of navigation chart preparation prior to commencing the simulator training.

Table 1. ASAT Curriculum (from Surface Warfare Officer School, n.d.)

Simulator Course	**Hours**
(CV-1) Cove—1 (Introduction to COVE/ Pier Work	4
(CV-1) Cove—1 (Pier Work with Environmentals)	4
(CV-1) Cove—1 (UNREP)	4
(CV-1) Cove—1 (Integrated DIVTACS)	4
(CV-1) Cove—1 (BRM Practical – NYC Harbor Transit	5
(CV-1) Cove—1 (BRM Practical 0 Hong Kong Harbor Transit	4
(NSS-9) Guam Transit / Precision Anchorage	4
Total Time	29

This pipeline training for DHs usually occurs seven to eight years after becoming a SWO and 10 to 15 years later for those screened to command ships at sea. This statement is based upon personal experience and survey results that are reported in Chapter V of this thesis.

The current SWO training design has changed and currently brings officers back to SWOS between their first and second division officer tours; however, there remains a gap onboard ships where resident expert knowledge is not available. This environment creates the potential for officers to develop habits in ship-handling that are not in accordance with the RoR. Even though these officers spend several weeks at SWOS in a ship-handling simulator(s) and lectures while attending SWOS, the habits that have culminated after three or more years of watchstanding on the bridge are hard to break in that short period of time.

SWOS continues to increase its standard of training by investing millions of dollars in the latest ship-handling simulation technology and developing scenarios that stress its officers who are there in attendance. Unfortunately, that training and experience is not sustained in the fleet. This ultimately allows an officer, regardless of commissioning source or fleet concentration area (FCA) assignment, who has received no extensive or customized training to revert to the habits they began developing as an ensign.

Currently, 72 COLREGS and Inland Navigation Rules are instructed in the traditional classroom format at SWOS, USNA, NROTC units, and onboard ships. The training consists of lectures, self-study, quizzes, and tests that can range from days to months depending upon where the training is being conducted. This method of instruction is valuable for understanding the fundamentals of the 72 COLREGS and Inland Navigation Rules; however, it does not provide the practical training that an officer needs to safely and confidently handle the ship in a variety of mentally demanding and stressful situations. A major problem domain with training onboard ships is that it cannot afford to conduct on-the-job-training (OJT) in this specific area with a multi-billion dollar warship because of

concerns for safety for the ship and crew, ship operations, or other training requirements that will supersede OJT for 72 COLREGS and Inland Navigation Rules.

Mentally demanding and stressful situations with other ships will probably not occur in a ship's training cycle while at sea, but will occur when the ship approaches its first strait transit in Europe or Asia. So understandably, officers are not exposed to every 72 COLREGS and Inland Navigation Rules situation because of the types of operations they are conducting during their training cycle. Moreover, the Commanding Officer's Standing Orders may prevent those situations from ever occurring unless the commanding officer (CO) is on the bridge or informed. In the rare instance a situation with another ship requires a bridge team to act in accordance with the 72 COLREGS and Inland Navigation Rules whether the CO is present or not on the bridge, being unprepared for the situation or not following the 72 COLREGS and Inland Navigation Rules could result in a collision, such as the *USS Porter* (DDG-78) collision on August 12, 2012.

Incorporating 72 COLREGS and Inland Navigation Rules training in ship-handling simulators can improve our practical knowledge of the 72 COLREGS and Inland Navigation Rules. Thus, this may keep ships out of harm's way when operating in the vicinity of other vessels, whether that is our own ships or others. The cost of implementing 72 COLREGS and Inland Navigation Rules training in ship-handling simulators is minimal because the software is already present and only scenarios would need to be developed that place users in real life situations involving the practical application of the 72 COLREGS and Inland Navigation Rules, such as a Strait of Hormuz transit. The benefits of training are not limited to our navy, but include other entities such as maritime institutions that are in the infancy stages with their own ship-handling simulator training.

B. SCOPE

The primary scope of this thesis was to demonstrate the usefulness of simulation technology in traditional classroom lectures, focusing on 72 COLREGS and Inland Navigation Rules. This thesis includes one research question and eight exploratory questions. Utilizing the Full Mission Bridge (FMB) simulator at SWOS and existing software, several scenarios were designed for the pilot study because the research needed to address the multiple situations and rules that arise from the 72 COLREGS and Inland Navigation Rules. In addition, this provided valuable feedback about the scenarios and an opportunity to gather data (i.e., demographics, survey responses, and test scores) from the participants so that data analysis could be conducted to answer the research and exploratory questions. The participants in the research study were volunteers who were enrolled in the Advanced Ship-handling and Tactics (ASAT) course at SWOS. Upon completion of the experiments, data analysis was conducted from the participants' responses and test scores. The thesis concludes with the results from our data analysis, recommendations, and future work.

C. RESEARCH QUESTION

Do students who use ship-handling simulator training achieve higher scores on a standardized 72 COLREGS and Inland Navigation Rules test than those who did not?

D. HYPOTHESIS

Participants who have ship-handling simulator training incorporated with their RoR lectures will achieve higher scores on a standardized RoR test than those who did not.

E. OTHER EXPLORATORY QUESTIONS

1. Does auditory and visual simulation enhance the participants' understanding of the 72 COLREGS and Inland Navigation Rules?

2. Were the scenarios provided by the research team realistic and did they contribute to the participants' understanding of the 72 COLREGS and Inland Navigation Rules?
3. Does auditory and visual simulation enhance the training session and contribute to the participants' understanding of the 72 COLREGS and Inland Navigation Rules?
4. In comparison with *United States Coast Guard (USCG) Navigation Rules, International—Inland* manual (Commandant Instruction M16672.2D), was the Full Mission Bridge (FMB) simulator more effective in teaching maneuvering schemes, lights, and sound signals to the participants?
5. Do participants feel that auditory and visual simulation technology should be incorporated in instructing Commandant Instruction M16672.2D?
6. Do participants feel more prepared to take a 72 COLREGS and Inland Navigation Rules test after completing the research teams sessions in respects to maneuvering schemes, lights, and sound signals?
7. Do participants feel that an interactive tool would be useful in maintaining 72 COLREGS and Inland Navigation Rules proficiency in the fleet?
8. If provided the opportunity, would participants use an interactive tool to maintain RoR proficiency?

F. DEFINITION OF TERMS

Advanced Ship-handling and Tactics: a SWOS course that is mandatory for non-qualified ensigns or lieutenant junior grades. The majority of the students are qualified on their ships as an Officer of the Deck or are attending the course through an approved waiver. The course is three weeks long and focuses on leadership, maritime warfare, navigation, and shiphandling.

Commanding officer's standing orders: OPNAVINST 3120.32D defines "orders" as a military order that is a formal oral or written command issued by a superior officer to a subordinate establishing a rule or regulation, or delegating authority for the performance of a function (OPNAV Instruction 3120.32D, 2012). Thus, for this thesis, commanding officer's standing orders are defined as a commanding officer's military order that prescribe procedures for shipboard

situations (i.e., small boat operations, launching or recovering aircraft, changing required reports from the officer of the deck for closest point of approach with vessels).

Fleet concentration area (FCA): Areas where large numbers of Navy ships are homeported and thus have additional resources to support the ships: Norfolk/Hampton Roads, V.A.; Jacksonville/Mayport, F.L.; San Diego, C.A.; Everett, W.A.; Pearl Harbor, H.I.; and Yokosuka and Sasebo, Japan.

High fidelity entity: A VShip object whose speed, individual engines, rudder, autopilot heading, lighting configuration, ship's whistle, and other features can be changed by the simulator operator. Lateral and longitudinal speed information is also available, which is critical while conducting pier work. The movement of this entity resembles real world ship characteristics and physics. In normal system configuration, this is the entity that user(s) of the FMB simulator will control through the helm and leehelm controls located in the FMB simulator. The monitoring of this entity is critical during simulator operation because it provides instantaneous feedback to the simulator operator. Figure 2 provides a screen capture of the characteristics of a high fidelity entity, in this case a guided-missile cruiser (CG), that the simulator operator will see while operating the system.

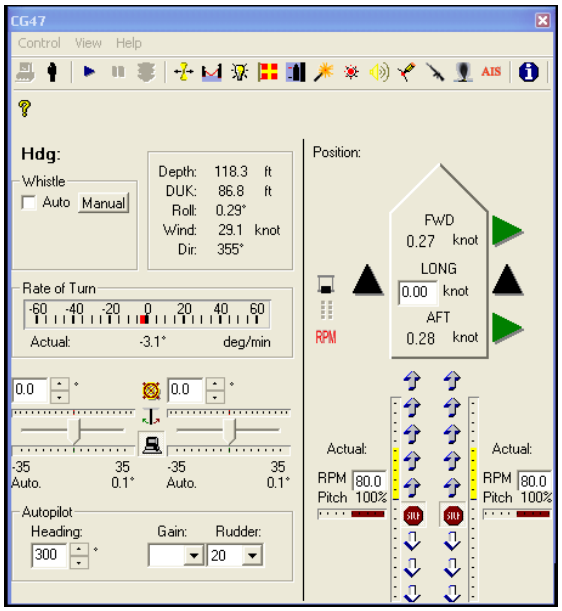

Figure 2. High Fidelity Entity Screen Capture

Inland Navigation Rules: “Inland Rules” or “Rules” and annexes that govern the conduct of vessels and specify the lights, shapes, and sound signals that apply on inland waters (Commandant, United States Coast Guard, 1999).

Inland waters: The navigable waters on the United States shoreward of the navigational demarcation lines dividing the high seas from harbors, rivers, and other inland waters of the United States and the waters of the Great Lakes on the United States side of the International Boundary (Commandant, United States Coast Guard, 1999).

International Regulations for Prevention of Collisions at Sea, 1972 (72 COLREGS): The multilateral treaty that is published by the International Maritime Organization, which set out navigation rules to be followed by ships and other vessels at sea to prevent collisions between two or more vessels outside of specific political inland waters (Wikipedia, 2013). The COLREGS include 38 rules divided into five sections: Part A: General; Part B: Steering and Sailing; Part C: Lights and Shapes; Part D: Sound and Light Signals; and Part E: Exemptions (Commandant, United States Coast Guard, 1999).

Low fidelity entity: A VShip object whose speed, heading, lighting configuration, ship's whistle, and other features can be changed by the simulator operator. Lateral and longitudinal speed information is not available. The movement of this entity does not resemble real world ship characteristics and physics; therefore, it must be manually manipulated by the simulator operator if such movement behavior is necessary. In normal system configuration, this entity is not controlled by the users of the FMB simulator. Figure 3 provides a screen capture of a low fidelity entity, in this case a tanker of 132 tons, that the simulator operator has the ability to see while operating the system. Unlike the high fidelity entity, monitoring this entity is not as critical during simulator operation since the user(s) are not controlling this entity from the FMB.

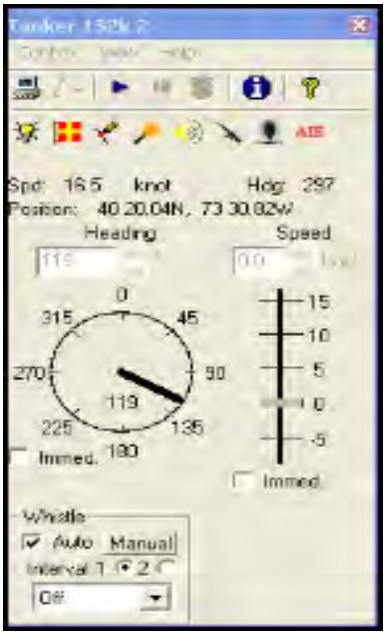

Figure 3. Low Fidelity Entity Screen Capture

Rules of the Road (RoR): 72 COLREGS, Inland Navigation Rules, or the combination of both.

G. MOTIVATION FOR RESEARCH

After teaching at SWOS for two months as a seamanship instructor, I observed that our officers (junior and senior) were consistently struggling with adhering to the rules of the road (RoR) while in the FMB and Conning Officer Virtual Environment (COVE) simulator. I decided to make my sessions with ASAT students more complex to determine where the gap was and asked students how we could improve the RoR lectures. I realized the gap had been applying what was instructed in the classroom to the practical scenario in the simulator. In short, students could pass a multiple choice RoR test after being lectured on the subject, but could not demonstrate that knowledge with action in a full-scale simulation.

I conducted additional research to determine if any studies have been done in this field relating specifically to incorporating simulation technology and classroom lectures; I found only one done at the California Maritime Academy. I contacted the author of that study, Captain James J. Buckley, who provided great assistance as to where the study should focus if I decided to pursue this thesis. With SWOS permission (Appendix P), I was able to review previous ASAT classes' RoR practice test scores and read the analysis report their system provided. After hours of reading and conducting my own analysis, I hypothesized that a gap existed in the auditory and visual realms of the RoR.

Simulators are a great teaching tool if time is invested in developing scenarios that challenge the user mentally; they apply stress that cannot be replicated in a classroom environment. This type of learning provides the opportunity for students to bridge the gap between knowledge and application, thus providing a realistic learning experience without jeopardizing personnel and military property damage. The Navy has the technology and resident expert knowledge to make a major impact on the existing RoR training in the fleet; it should not take the loss or injury of personnel and damage of equipment or ships to implement change in the curriculum where simulators are available.

H. BENEFITS OF STUDY

This research has the potential to demonstrate that if RoR simulation training is used in conjunction with traditional classroom RoR lectures, the effects of simulation training will increase that individual's understanding of the RoR and provide practical experience without jeopardizing the safety of a real ship. Additionally, this study highlights the capabilities of existing hardware and software that are available to train our officers and enlisted personnel in the RoR. This thesis supports the need for increasing simulation technology in curricula that have been traditionally instructed only in a classroom environment. Moreover, this type of training will only aid in teaching the current and future generations of officer and enlisted personnel who are already institutionalized with simulation and game based technology. Future work should examine the effectiveness of teaching the RoR with simulation technology onboard ships and at FCA training facilities that have simulators.

I. THESIS ORGANIZATION AND TABLE OF CONTENTS

Chapter I: Introduction. This chapter presents the study's problem statement, background, objectives, research question, hypothesis, exploratory questions, definitions of terms, motivation, and benefits.

Chapter II: Background. This chapter discusses previous research that has been conducted with simulation technology, learning techniques, and current naval ship-handling simulators.

Chapter III: Methodology. This chapter describes the type of experiment design, research equipment, and study measures. Additionally, it discusses demographics of participants, scenario design, and overview of the procedures used to conduct the study.

Chapter IV: Pilot and Experimental Group Study. This chapter provides, in detail, the pilot and experimental group scenarios.

Chapter V: Results. This chapter provides the descriptive statistics of the study and an analysis of those results.

Chapter VI: Summary, Discussion, Recommendations, and Conclusions. This chapter provides an overall summary, hypothesis and exploratory discussion, limitations and lessons learned, future work, and recommendations of the researchers.

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II. BACKGROUND

A. INTRODUCTION

The Navy is in the process of procuring additional ships for its fleet because of increased advances in technology and the aging of its ships. The Navy's five year proposed shipbuilding procurement plan, fiscal years 2014 through 2018, seeks to build 41 ships (O'Rourke, 2013). These ships include, but are not limited to submarines, surface combatants, and supply ships. With the fiscal constraints already placed on ships that reduce their time at sea and the coming of additional ships, ship-handling simulators in the fleet will only need to increase to meet the training demands of the ships and to maintain the proficiency of its bridge watchstanders. Currently, the Navy utilizes the following ship-handling simulators in the fleet to train the personnel who drive these ships: Navigation, Seamanship, Ship-handling Trainer (NSST), Conning Officer Virtual Environment (COVE), Full Mission Bridge (FMB)/Tactical COVE (TACOVE) Ship-handling Simulator, Littoral Combat Ship (LCS) Bridge Simulator, and Full Mission Ship-handling Simulator (Reber & Bernard, 2012).

B. STRAIT OF HORMUZ AND USS PORTER COLLISION

The Navy navigates in every high density strait in the world, such as the Strait of Hormuz. The bridge team that navigates that strait must be proficient and knowledgeable in the RoR and must also know how to deal with the stress that is part of that transit. If the team is not prepared, risk of collision or collision between that warship and another vessel may occur.

As Figure 4 shows, the Strait of Hormuz is approximately 175 miles long, at its narrowest point 21 miles wide, with a traffic separation lane approximately two miles wide, which can make for a long transit depending upon traffic conditions (Wikipedia, 2013; USNI News, 2013).

Figure 4. Strait of Hormuz (from Energy Information Administration [EIA], 2012)

According to the U.S. Energy Information Administration, this strait transported 17 million barrels of crude oil per day, making up almost 20 percent of oil traded worldwide (EIA, 2012). It is perhaps the most important strait in the world because it enables oil producing Middle Eastern countries to export their oil throughout the world. As a result, many countries' navies frequently transit it to ensure this strait remains safe for the commercial vessels that utilize it and while en route to the Persian Gulf to carry out their nation's strategic mission.

Based on extensive personal experience of having transited this strait over a dozen times as a Surface Warfare Officer (SWO), no transit through this strait was identical to the last. The only variable that remained constant during these transits was the weather conditions because they were during the summer. The time of day, speed, sea state, radio traffic, and traffic density varied immensely. In addition to these variables, there was always a high level of stress throughout the ship because of the attention our ships naturally draw from other countries when we make this transit as a battle group or independently. As a result, this stress level is the most intense on the Bridge and in the Combat Information Center (CIC), especially when operating in close proximity to other vessels at speeds that the RoR would define as unsafe based on the prevailing circumstances.

Unfortunately for the *USS Porter* (DDG-78) and her crew, the stress level, traffic density, background lighting, time of day, speed, and other factors resulted in her collision at 12:53 on August 12, 2012 with oil tanker, *Otowasan*, as *USS Porter* continued to alter her course to port to avoid other vessels (Fellman, 2012). Despite all of these factors, if the bridge watchstanders had been more proficient in their knowledge of the 72 COLREGS during an extremely stressful situation, this collision may have been avoided. Figure 5 shows the damage she sustained from the collision (Casey, 2012). The cost to repair the *USS Porter* will cost the Navy approximately $49 million, months in the shipyard, millions in costs to the owners of the *Otowasan* and more tragically, unknown psychological effects on the crew. Ultimately, the commanding officer was relieved of command due to loss of confidence in the ability to command. Fortunately, no lives were lost.

Figure 5. *USS Porter* (DDG-78) Starboard Side Damage (from Casey, 2012)

As stated earlier, the Navy has some of the best simulators in the world to train its bridge watchstanders in navigation, but the main gap is in the priority of

its training and in the implementation of its curriculum for these simulators. The Navy has implemented a more stringent qualification program for its future PCOs in which utilization of these simulators is one major part of the qualification exam. These officers must take several tests including a RoR test where the minimum score is 90 percent, and several ship-handling evolutions in the FMB (COMNAVSURFPAC & COMNAVSURFLANT, 2012). This process helps in ensuring the Navy is getting SWOs who are prepared to assume command-at-sea.

C. TRANSFER OF TRAINING

There is strong quantifiable evidence that suggests simulation training is just as effective as traditional training methods and that there is a positive transfer of training when simulators are used. In his study utilizing the *Virtual Battlespace 2™* (VBS2) virtual sandbox, Brown concluded that simulation training was at least as effective as traditional methods of training when applied to small tactical units. Additionally, he concluded that the trainer must be proficient in the area and simulator they are using to instruct on (Brown, 2010). A similar study was conducted by the U.S. Army Research Institute utilizing VBS2 and they also concluded that VBS2 provided positive transfer of training at the individual and unit level for its participants (Ratwani, Orvis, & Kerr, 2010). Jensen and Woodson also proved that simulation technology was just as effective as traditional training in their marksmanship study that utilized the Fire Arms Training Simulator and that there is positive transfer of training when simulation is used (Jensen & Woodson, 2011).

Positive transfer of training is being accomplished through simulation technology. Measuring its effectiveness is also becoming simpler if there are variables that can be quantifiably measured in that simulator or via a feedback survey. For maritime simulators, measuring the effectiveness is more challenging because there are many intangible skills being learned that are acquired through implicit learning, which make it difficult to measure (Ellis, 2005).

For example, the U.S. Navy incorporated a blended training program that consisted of instructor-led classroom training and simulator sessions for the Iraqi Navy in order for the Iraqi Navy to take delivery of 15 35-meter patrol boats purchased from the U.S. (Faram, 2010). In addition, the utilization of simulation technology was critical in this training and to maintain training proficiency according to Captain Ed Turner, former commanding officer, Naval Education and Training Security Assistance Field Activity. In this case, simulation technology was an appealing solution because the Iraqi Navy was not familiar with the U.S. Navy's vessels and needed an aggressive training program, the U.S. Navy along with other countries have been protecting their oil platforms since 2003, and they were revitalizing their navy that was destroyed during the 1990—1991 Persian Gulf War (Faram, 2010). In this case, training appears adequate, as they have been successfully operating these patrol craft since the final delivery of PB 312 on July 5, 2013 (Defense Industry Daily staff, 2013).

In other cases, being able to evaluate the effectiveness of how simulation training transfers to a real life event can be extremely difficult. The participants who use these simulators often provide subjective answers that are non-quantifiable and only suggest anecdotal evidence in its effectiveness (Peck, 2012). Moreover, capturing the effectiveness of how that simulation is transferred to the real world is solely based on that individual's or group's feedback. Despite these challenges, simulation training is one of the primary training tools utilized by all the armed services.

D. THE INTEGRATION OF IMPLICIT AND EXPLICIT LEARNING

Ellis (2008) defined implicit learning as the acquisition of knowledge about the underlying structure of a complex stimulus environment by a process that takes place naturally, simply and without conscious operations. He also stated that explicit learning is a more conscious operation where the individual makes and tests hypotheses in a search for structure. Based on this, Ellis concluded that knowledge attainment can thus take place implicitly (a non-conscious and

automatic abstraction of the structural nature of the material arrived at from experience of instances) or explicitly through selective learning (the learner is searching for information and building and then testing hypotheses). In other words, explicit learning is a style that consists of writing down words, memorizing what they mean, and drawing hypotheses about them (Vocabulary Studies, 2013) while implicit learning takes place incidentally (Shanks, 2003) or learning without awareness (Frensch & Rünger, 2003).

In my experience, ship-handling instructors at Navy training facilities generally do not have the same teaching credentials found at maritime or academic institutions. Even though they may lack this type of training, they possess the proper qualifications to lead maritime instruction based on navigation and ship-handling experience, maritime knowledge, and years at sea serving as COs onboard warships or civilian captains onboard commercial vessels. Therefore, developing a curriculum that incorporates implicit and explicit learning techniques may be foreign to them.

Sun and Mathews concluded that the integration of implicit and explicit learning techniques enables students to respond faster and more accurately when conducting a task (Sun & Mathews, 2005). The results of their research imply that the integration of implicit and explicit learning techniques is superior to implicit or explicit learning technique when these styles of learning are presented individually. Sun et al. would later postulate that implicit and explicit learning needs to be integrated in the model of skill learning because it accounts for the various effects of the implicit and explicit interaction in learning (Sun, Zhang, Slusarz, and Mathews, 2007). One of the most beneficial aspects of allowing these two types of learning techniques to interact with each other in learning a skill, such as navigation and ship-handling, is that the individual can readily act while understanding and being knowledgeable about the sets of rules they just applied.

E. MARITIME SIMULATION TRAINING

Even though the above studies concentrated solely on personnel who are primarily conducting some type of security patrol or marksmanship exercise with a simulator, there is also evidence showing the usefulness of simulators in the maritime field. For ship-handling, it is imperative that the mariner be exposed to the explicit and implicit learning styles while conducting his or her training because they must be knowledgeable in all facets of navigation and ship-handling. The explicit knowledge they gain from the classroom will be instrumental in the ability to read charts, weather, and other resources that must be used as a mariner. The implicit knowledge they gain from a simulator can be useful for understanding how a ship maneuvers in various conditions while operating in harbors to open ocean, and when in a situation where they must observe the 72 COLREGS. One can read the above and state that is an easily achievable goal for a training facility to implement, but it is not.

One would expect that USNA and NROTC units would be immersed in RoR and ship-handling training like their maritime institution counterparts. The fact is they are nowhere near comparable. Unlike maritime institutions, the USNA and NROTC units do not have a specialized curriculum that is tailored just towards navigation and ship-handling (e.g., Marine Deck Officer). The USNA and NROTC units spend only approximately 14 academic school hours focused on RoR training, seven navigation classes (J. Noda, personal communication, October 29, 2013; USNA, 2013) that incorporate RoR and simulator training, and several weeks at sea for one summer onboard a yard patrol craft (USNA students only). Their maritime institution counterparts whose curriculum specializes in navigation and maritime transportation will spend four years at that institution immersed in curriculum that involves navigating and operating a ship (SUNY Maritime College, 2013). The expectation from the fleet is that our bridge watchstanders are proficient in navigation, but when compared to their maritime counterparts, they are years behind.

While there is no formal data on the use of fleet ship-handling simulators, based on personal experience as a SWO and instructor, we primarily used our simulators for ship-handling evolutions. Unlike maritime academy graduates, newly commissioned officers are generally not as proficient and knowledgeable when reporting onboard their first warship. However, the Navy expects this gap to be minimized because, after reporting, they have the opportunity to train using ship-handling simulators to help them become knowledgeable about ship-handling. The largest problem with this expectation is that there are over 200 other ships trying to conduct the same training for their bridge watch team. In some instances, junior officers express that this training is insignificant because our ships utilize tugs when getting underway and use the ship's rigid-hull inflatable boat (RHIB) if there is a person overboard. Although these special evolutions are infrequent, ship-handling training must be maintained at its current levels because these evolutions are inherently dangerous to the ship, crew, and environment. However, more time needs to be allotted to training bridge watch teams to safely navigate our ships in everyday operations.

Incorporating ship-handling simulators in RoR lectures is in its infancy stages, and to date there has only been one study showing the benefit of using them in training bridge watchstanders. Dr. Sam Pecota integrated his RoR lectures with simulation technology at California Maritime University and concluded that his students were performing better on practical and written exams involving the RoR than those who did not receive the integrated training (S. Pecota, personal communication, October 19, 2013). Unable to quantifiably measure if students learned implicitly, it could be inferred that they did from the subjective responses on post survey reports (Buckley & Pecota, 2009). Unlike the institutions that have the ability to focus their training on navigation and maritime transportation, the fleet's training requirements and deployment cycles limit the time that ships can train to the level of maritime institutions. These constraints and others, make it a challenge to incorporate both learning techniques in RoR training, especially in FCAs.

F. U.S. NAVY SIMULATOR RESOURCES

The Navy has multiple ship-handling simulators in its fleet. In particular, the Navy focuses on Polaris V1 and V2 to meet its training requirements as outlined by its representative type commander (TYCOM). COMNAVSURFORPAC and COMNAVSURFLANT define these two simulators as (COMNAVSURFPAC & COMNAVSURFLANT, 2012):

1. POLARIS V1

COMNAVSURFPAC & COMNAVSURFLANT describe Polaris V1 as a small foot print trainer whose training audience is the conning officer and/or officer of the deck. The benefits of this system are that it is a stand-alone, single person trainer consisting with an embedded coaching capability. The hardware consists of a helm console and three flat panel displays while the software has pre-built specific scenarios reflective of homeports and ship hull characteristics.

2. POLARIS V2

Polaris V2 is shown in Figure 6. COMNAVSURFPAC & COMNAVSURFLANT describe Polaris V2 as a FMB simulator that supports individual and watch team training. Similar to Polaris V1, the maneuvering characteristics are virtually identical to real ships, but are augmented by high fidelity radar, navigation instruments, and high fidelity large screen displays that provide 180 degrees field of view. Unlike Polaris V1, the Polaris V2 requires an operator to control the simulator and support the training.

Figure 6. POLARIS V2 (from U.S. Navy takes Delivery of Full Mission Simulators, 2004)

Understanding the necessity and demand of ships to train on these simulators while not at sea to help maintain ship-handling proficiency, the TYCOMs have placed minimum training requirements on ships as shown in Table 2.

Table 2. Navigation, Seamanship, Ship-handling, and Training (NSST) Requirements (from COMNAVSURFPAC & COMNAVSURFLANT, 2012)

NSST Course	Requirement and Type of Simulator Used
Bridge Resource Management (BRM)	Complete one BRM course every 27 months. Course is 40 hours in length and V2 simulator is utilized.
Special Evolution Training	Complete 28 hours of training within 12 months, V2 simulator utilized. Ship can request up to 32 hours of additional training.
Basic Ship Handling (BSH)	Complete one BSH course every 27 months. Course is 40 hours in length and V2 simulator is utilized.
Polaris V1 Refresher	Recommended every 27 months. Course can be up to 24 hours in length. V1 simulator is utilized.
Ship-only Training	Recommended. NSST instructors are not available for instruction.

SWOS Newport utilizes three ship-handling simulators similar to the Polaris V1 and V2. COVE I and COVE III simulators at SWOS Newport would be comparable to the Polaris V1 while the FMB I simulator would be comparable to Polaris V2. The third simulator at SWOS Newport, FMB II, provides a near 360

degree field of view from bow to stern and waterline to sky. FMB II will not be discussed in this thesis because it was in the developmental stages while this study was conducted.

3. COVE I

COVE I is the primary means for teaching students who are enrolled in the Basic Division Officer Course (BDOC) and ASAT course at SWOS Newport and select FCAs. COVE I uses a head-mounted display (HMD) as the primary method of visual and auditory delivery. The system hardware consists of: HMD integrated headphones, hand-held microphone, joystick, seven monitors, three keyboards, and VHF radio as shown in Figure 7. The students can utilize all of the hardware with the exception of two monitors and one keyboard that is reserved for the instructor. The monitors that the students have access to show their chart position, radar picture, ship's rudder angle, engine order, heading, speed, and relative wind. If operating a FFG or MCM, bow thruster position is also displayed. Normally, the student only needs to look at one monitor that shows the rudder angle position, engine order, heading, course, speed, relative wind, and bow thruster position (FFG and MCM only). The qualification process for these instructors is described later in the chapter.

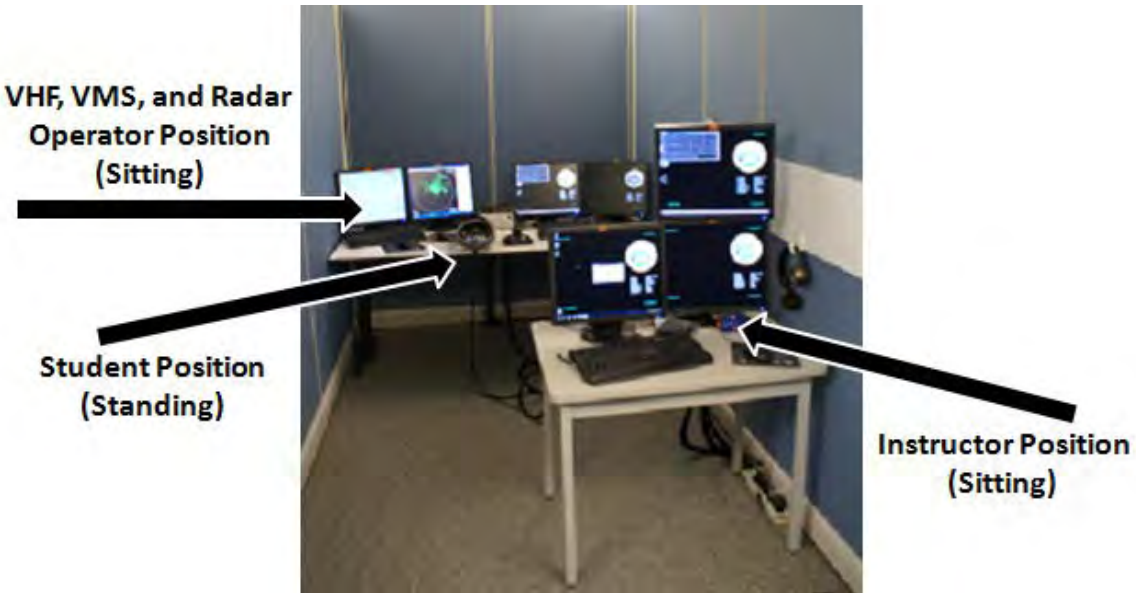

Figure 7. COVE I: Instructor, Student, VHF, VMS, and Radar Operator Positions

4. COVE III

COVE III is the primary means for teaching DHs, PCOs, and major command officers enrolled in the DH Course and PCO/Major Command course. It is known as COVE III because the primary method of visual and auditory delivery for the simulator is the three large television screens and speaker system. The system hardware consists of: HMD with integrated headphones, hand-held microphone, joystick, seven monitors, three keyboards, three large television screens, interactive media whiteboard, and Very High Frequency (VHF) radio as shown in Figure 8. The students can use the HMD if they prefer rather than the television screens. Unlike COVE I, the students can only utilize the three television screens, two monitors, and hand-held microphone. All other equipment is operated by additional students if that evolution requires it.

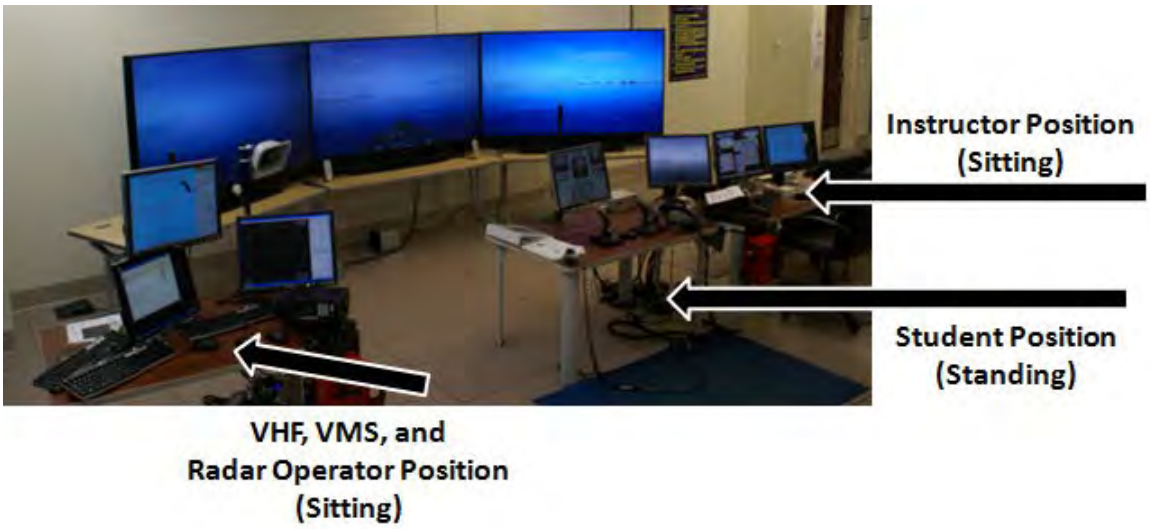

Figure 8. COVE III: Instructor, Student, VHF, VMS, and Radar Operator Positions

Additional details of these simulators can be found in LTs Reber and Bernard thesis (Reber & Bernard, 2011).

5. FMB

FMB is discussed in Chapter III, Methodology.

6. SWOS NAVIGATION AND SHIP-HANDLING INSTRUCTOR QUALIFICATION

SWOS ship-handling instructors receive extensive simulator and classroom training prior to becoming a ship-handling instructor. The majority of these instructors have completed two division officer tours and are assigned as staff for this tour, waiting to attend department head (DH) school, or are transitioning to the civilian community. They are qualified by Captain (Retired) Bud Weeks, Director of Naval Shiphandling and Seamanship at Surface Warfare Officers School and former Commanding Officer of several naval warships, and trained by his staff that also consists of retired commanding officers, former merchant marine captains, and other highly qualified USCG licensed merchantmen. These staff members are primarily responsible for the training

and assessment of DH students, prospective commanding officers (PCO), and major command officers in navigation and ship-handling, and simulation re-creation of warship accidents at sea, such as the *USS Porter* collision. Other members of his staff include select lieutenant commanders and lieutenants who are post-DHs or served as navigators onboard warships prior to reporting to SWOS Newport. They are responsible for instructing navigation, seamanship, and ship-handling courses to ASAT students.

All ship-handling instructors complete a rigorous qualification process that is both written and practical in nature. The written portion consists of scoring a 90 percent or above on a 50-question multiple-choice RoR test that has over 1,000 questions in its test bank. This test bank comes from the USCG and is validated by Captain Weeks's staff. If an instructor fails this exam twice in a row, he or she is required to hand-write the entire Commandant Instruction M16672.2D; there have only been a few to do this. Individuals that fail a third time are referred to the commanding officer of SWOS.

The practical portion of the qualification process consists of successfully completing multiple ship-handling evolutions utilizing COVE III with his staff of civilian instructors within the limitations of that evolution. The evolutions involve pier work, man overboard, underway replenishment, anchoring, transiting into Bahrain, and docking/undocking in Bahrain with wind speed of 15 knots and 0.5 knots of current. Additionally, the instructor must be able to complete pier work evolutions on three different ship classes whose propulsion systems are different. The propulsion systems are single-screw variable pitch, twin-screw variable pitch, and twin-screw fixed pitch. The final part of the qualification process is completing one evolution of pier work and underway replenishment with Captain Weeks himself who will vary the environmental conditions, induce steering or propulsion casualties, and ask questions ranging from navigation to the ship's characteristics that the instructor is conning.

This qualification process normally takes up to 90 days once he or she has completed other departmental requirements. RoR proficiency is maintained

by taking a RoR test semi-annually with a required minimum score of a 90 percent while ship-handling proficiency is tracked through his or her respective department. In addition to this qualification, instructors are qualified on the setup and operation of these simulators. Training is conducted by qualified operators and civilian contractors who maintain the equipment. Instructors can receive additional training in scenario design if so desired from the Director of Naval Shiphandling and Seamanship at SWOS staff or FMB operators.

G. TRAINING REDESIGN

There are numerous studies that show simulation training can result in both positive and negative transfer of training (it is not the intent of this thesis to summarize each of those studies). Additionally, it is common knowledge that the military is heavily invested in simulation technology for its training and it proves to be one of the most cost-effective training tools (Rand, 2003; 2005). This study will incorporate the interaction of implicit and explicit learning techniques to show that simulation technology improves an individual's score on an exam and their practical understanding of the information acquired. Moreover, it will demonstrate how existing simulators' hardware and software can be utilized to increase and maintain the proficiency and knowledge base of the fleet.

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III. METHODOLOGY

A. OVERVIEW OF THE RESEARCH DESIGN

This study uses a quasi-experimental research design based on comparison-group design (Stangor, 2011). The study consists of a treatment group and control group. The treatment group consisted of ASAT student volunteers who were not randomly selected because of time constraints, resources, and participation. The control group consisted of previous ASAT student data from classes 280 through 288. These students' RoR practice test scores were only accessible and no demographic information was made available to the researchers. The researchers assumed their mean demographics were the same as the treatment group based on occupation, rank, and enrollment in the ASAT curriculum. The independent variables of this study were exam scores, incorporation of simulation technology for classroom based lectures, and the application uses of simulation technology.

The research team measured the independent variables by comparing the treatment and control groups' RoR practice test scores and measuring subject responses in the demographic survey and post-questionnaire between the treatment groups. This thesis research was approved by the Naval Postgraduate School (NPS) Institutional Review Board (IRB); IRB approval number NPS.2012.0069-EP7-A.

B. PARTICIPANTS

All participants and previous ASAT students were active duty USN with the exception of one who was active duty USCG. All participants attended the ASAT course at SWOS Newport. The treatment group consisted of 27 participants, six in the pilot study group and 21 in the experimental study group. The control group consisted of 341 individual ASAT practice RoR exam scores.

All participants in the pilot study group were asked to complete a RoR pre-study test. Of the six participants, one did not take the test because enrollment

in the study was after the other participants completed their pre-study test. All participants in the research study completed a demographic survey prior to their treatment session. Table 3 summarizes their demographic information and Appendix A shows the demographic survey and summary statistic of that data. Information regarding the participants' age, sex, and ethnicity was not collected because it had no direct relevance in the study. Of note, 23 of the 26 participants never utilized ship-handling simulators specifically for RoR training prior to this study.

Table 3. Demographics and Pre-Questionnaire

Commissioning Source	**USNA**	**NROTC**	**OCS**	**USCGA**			
	8	7	11	1			
Months Onboard Ship	**12 – 18**	**Greater than 18**					
	22	5					
Frequency of RoR Examination	**Months**						
	0	**1**	**2**	**3**	**5**	**6**	
	9%	32%	4%	44%	4%	8%	
OOD Qualified	**Yes**	**No**					
	22	5					
Months OOD Qualification	**Months**						
	0-3	**4-6**	**7-more**				
	62%	29%	9%				
Deployed Overseas	**Yes**	**No**					
	23	4					
OOD While Deployed	**Yes**	**No**					
	11	9					
Ship-handling Simulator Exposure	**Yes**	**No**					
	26	1					
Emphasis Placed on RoR	**Yes**	**No**					
	3	23					
Simulation Technology is an Effective Tool for Training	**Strongly Agree**					**Strongly Disagree**	
	7	**6**	**5**	**4**	**3**	**2**	**1**
	25.9%	55.5%	11.1%	3.7%	0%	3.7%	0

C. RESEARCH EQUIPMENT

The FMB simulator located at SWOS in Newport, RI was utilized for this study. SWOS Newport is the only U.S. Navy training facility that has an immersive, 360 degree field of view simulator capable of training an entire ship's bridge watchteam in ship-handling, at-sea force protection, and navigation. The FMB simulator consists of two major system components: Problem Control and FMB.

1. PROBLEM CONTROL

Problem Control is where the operators (one enlisted operator and one to two officer instructors) design and control scenarios for the FMB. Figure 9 shows the 27 monitors in Problem Control that enable the instructors to observe the students' actions in the FMB, monitor the view in FMB, and control the FMB using a keyboard and mouse.

Figure 9. Problem Control

In addition, the instructors can hear what the students are discussing utilizing the audible monitoring system and respond to students if they speak on the VHF radio, Navy Red, Net 15, or other simulated communication circuits.

This visual and two-way communication system helps provide immersive and instantaneous feedback to the student and is a critical component for effective training. Other equipment in Problem Control includes: two RHIB stations; Intelligent Aggressor Desktop; radar; VMS; and Optical Sight System (OSS). The operators under instructor supervision have the ability to take control of the FMB and its associated equipment at any time during the course of instruction.

2. FULL MISSION BRIDGE

As shown in Figure 10, the Full Mission Bridge (FMB) is where the student will conduct their training with the assistance of an instructor depending upon the scenario and level of instruction (ASAT, DH, or PCO/Major Command).

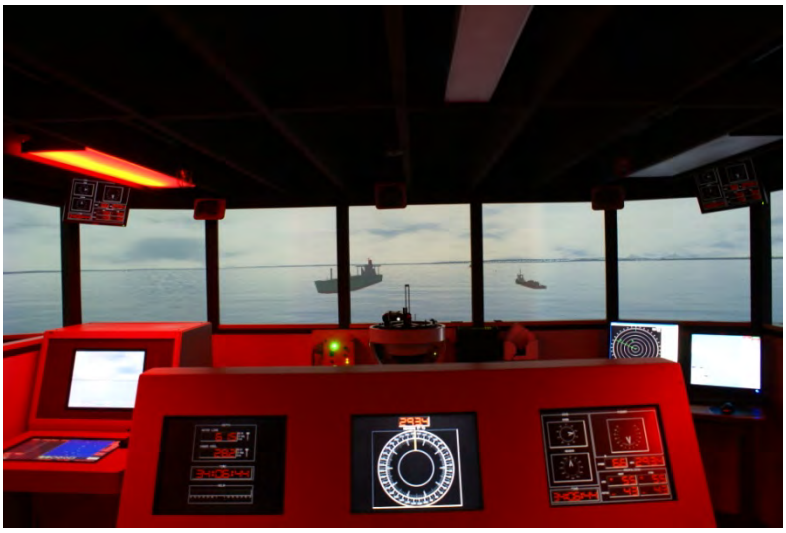

Figure 10. SWOS Newport Full Mission Bridge

Every student is given an equipment familiarization brief by the enlisted operator inside the FMB. The enlisted operator will demonstrate and address any questions regarding the FMB's binoculars, pelorus, radar, VMS, helm and lee console, ship's whistle, OSS, speed and course monitors, and communication circuits. The FMB is supported by 12 screens which measure 10 feet wide and 10 feet tall. These screens provide the 360 degree field of view of the environment and aspects of the ship.

In this study, no enlisted operator was used to operate the simulator or provide a familiarization brief to the participants. The researchers operated the simulator and provided the familiarization brief since they were qualified FMB and ship-handling instructors. After examining the necessary requirements to complete this study, participants were restricted to the following pieces of FMB equipment: binoculars, pelorus, radar, VMS, ship's whistle, OSS, and speed and course monitors. The ship was controlled from Problem Control when given the steering or propulsion order from the participants through the auditory system.

D. STUDY MEASURES

1. Demographics

A demographic survey was administered to the treatment group, which contained questions about education, naval career progression, and simulator experience (Appendix A).

2. RoR Post-Test

A RoR post-study test was administered to the treatment groups. The pilot study group practice RoR post-study test (Appendix B) contained similar questions to the experimental and control groups' practice RoR post-study test (Appendix C). The experimental and control groups' practice RoR post-study tests were exactly the same. The control group's practice RoR test scores were provided by LT Zieroth (2012) for ASAT classes 280 through 288 for the test analysis provided by perception (Appendix D).

3. Post-Questionnaire Survey

A post-questionnaire survey was administered to the treatment groups regarding the participants' FMB simulator experience in response to RoR stimulus training (Appendix E).

E. FMB SCENARIO DESIGN

1. Pilot and Experimental Study Group

Initial design of the scenarios was completed on Chart 12326, "Approaches to New York." This design was transferred into the FMB simulator utilizing the VShip software that is the main software program for the FMB simulator. Only one high fidelity entity was created and multiple low fidelity entities were chosen or duplicated from VShip's vessel library. These entities included, but were not limited to: large cargo carrying vessels; various tug towing configurations; pleasure craft; USN vessels; cruise ships; helicopters; and smoke floats (Appendices F–I).

The visual effects of motion in varying sea states can induce motion sickness on its users. These risks were mitigated by zeroing the sea state, wind, wave height, and current in the scenario design. There were variations in type of visibility, visibility range, and time of day depending upon the treatment session and scenario. Table 4 summarizes the global environmental settings that were used when developing the scenarios for the treatment session to mitigate the risk of participants experiencing motion sickness.

Table 4. VShip Global Environmental Settings

Environmental	Variable
Sea State	0
Wave Height	0
Wind	0
Current	0
Type of Visibility	Various (Clear and Storm)
Visibility Range	Various (13 nautical miles to 500 yards)
Time of Day	Various (Simulator Time)

F. PROCEDURES

1. Pre-Treatment Session

Approximately one hour prior to the participants arriving to the FMB simulator, the simulator was initialized, scenarios loaded and verified, and all necessary equipment for the session was operationally tested. If equipment was not operational, SWOS technicians were readily available to assist the research team prior to the participants arriving.

For the first treatment session, all participants completed the demographic survey, RoR pre-test (pilot study group only), and reviewed and signed the Standard IRB Consent Form after the researcher read it to them. The purpose of the study was restated and any concerns or questions the participants had regarding the study were addressed. The pilot study group received a study log (Appendix J) that was to be used to keep track of their study hours for the RoR post-test; however, none of them completed it. All participants received additional study aids (Appendices K-L) to assist them in their studies. Appendix K was provided from SWOS (2012). Appendix L was taken from the Submarine on Board Training website (2012).

Upon completion of all administrative documents and consenting to the study (Appendix M), the participants received a familiarization briefed on the equipment used in Problem Control and in the FMB. Demonstration of the equipment to be used in Problem Control and FMB for the study was conducted at this time as well. Any concerns or questions regarding the equipment to be used were addressed by the research team prior to the treatment session.

Participants were informed that they were not being evaluated for their ability to issue standard commands and that correct feedback would be provided, regardless of the way the steering or propulsion order was provided. The researcher offered standard command scripts (Appendix N) to the participants prior to the treatment session; none of the participants requested these documents.

For each additional treatment session (pilot study group only), lessons learned from the previous treatment session were provided by the research team. A re-familiarization brief of FMB equipment was provided, if so desired, and scenario objectives for that session were briefed.

2. Treatment Session

Utilizing the FMB and designed scenarios, participants were asked to safely navigate in open-ocean and densely populated waterways while in restricted and unrestricted visibility. These tasks were performed as a group consisting of no more than six participants. Participants were not assigned a designated bridge role such as the officer of the deck (OOD), Conning officer, helmsman, or other roles while a ship is underway. Participants were still required to utilize all available FMB equipment and provide steering and propulsion orders to the researcher. This enabled all participants to participate without having to be concerned with positional authority or having to focus on operating the helm and leehelm in the FMB.

3. Interaction of Research Team during Treatment Sessions

All attempts to interact with the participants were minimized throughout the treatment sessions. Interaction only occurred when the researcher responded to steering and propulsion orders, rule clarification, and when participants applied the inappropriate action based upon the situation in the scenario. As qualified SWOS instructors, the research team was obligated to provide instantaneous or delayed feedback when an inappropriate decision was made. This feedback was provided to assist in providing positive and effective training. When this feedback was required, the scenario was paused, situation discussed regarding that specific rule, and scenario resumed with the exact same situation so that the correct decision could be executed by the participants.

2. Post Treatment Session

Upon completion of the tasks, participants were required to wait 24 hours before they were allowed to take a RoR post-study test and post-questionnaire.

G. PILOT TESTING AND EXPERIMENTAL STUDY TREATMENT SESSIONS

Pilot and experimental study group treatment sessions are discussed in Chapter IV.

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IV. PILOT AND EXPERIMENTAL GROUP STUDY

A. PILOT STUDY GROUP: TREATMENT SESSION ONE

As previously discussed in Chapter III, all preliminary administrative documents and FMB familiarization were conducted in this session. This treatment session consisted of two scenarios with a scheduled time to complete this session of 60 minutes. It took the participants approximately 60 minutes to complete this session. A total of 44 entities were utilized with associated geography for these scenarios. Appendix F lists all the entities used in this scenario. The following paragraphs summarize the scenarios of this treatment session.

1. Treatment Session 1, Scenario 1

Scenario 1 consisted of 13 entities, one high fidelity and 12 low fidelity entities. The participants were placed onboard an anchored CG at a starting point of 040.19.88 North Latitude and 073.30.42 West Longitude. The simulator time for this scenario was 20:08 (30 minutes prior to sunset) and had a run time of 12 minutes. Visibility for this scenario was limited between 155 to 700 yards by building a fog layer that encompassed the CG 360 degrees. The purpose of this was to limit the participants' field of view so they could not see the entities that were in the background, which would be used in scenario 2. During design testing, the research team discovered that it was more realistic to have the entities already in place rather than adding them in the scenario as it was running. Table 5 summarizes the objectives that were to be completed by the participants in this scenario.

Table 5. Treatment Session 1, Scenario 1

Objectives	
1.	Operate FMB equipment and become familiar with the assigned ship participants are placed on for treatment sessions.
2.	Observe the different light configurations, sound signals, and length for vessels.

When the scenario was in run, the participants observed a “parade of ships” that included these 11 different types of vessels.

- not under command (NUC)
- restricted in ability to maneuver (RMD)
- tanker who was greater than 50 meters in length
- tanker less than or equal to 50 meters
- power boat less than 12 meters
- pilot vessel
- trawling vessel
- fishing vessel
- tug pushing a barge in international waters
- tug towing alongside in inland waters
- tug towing astern in bow international and inland waters

All these vessels displayed their respective navigation lights and sounded their sound signals for operating in restricted visibility as they crossed the bow of the CG at a range of 400 to 520 yards. The researcher was in the FMB simulator with the participants in this scenario and answered any questions the participants had regarding these vessels. The researcher referred and cited Commandant Instruction M16672.2D when answering all questions regarding these vessels. Figure 11 shows the ships surrounding the CG and several low fidelity tracks with their speed and time to reach waypoint (fog layers were removed for better visibility of the entities in this figure).

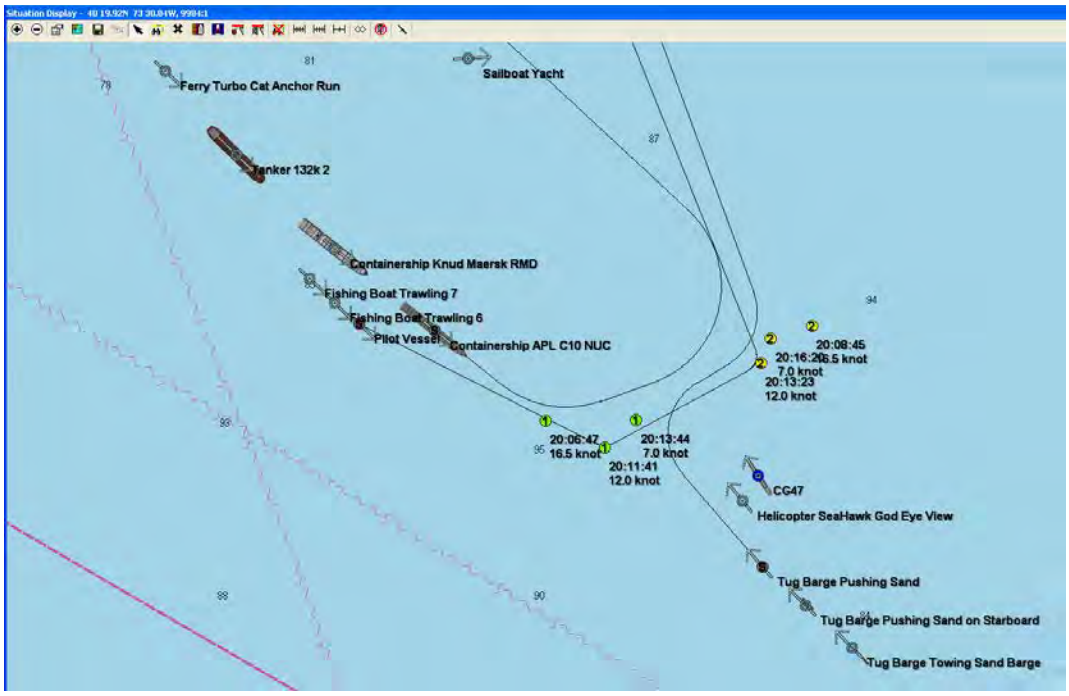

Figure 11. Pilot Study Group: Treatment Session 1, Scenario 1

2. Treatment Session 1, Scenario 2

Scenario 2 utilized the already created entities from scenario 1. Table 6 summarizes the objectives that were to be completed by the participants in this scenario.

Table 6. Treatment Session 1, Scenario 2 Objectives

Objectives	
1.	Proceed towards traffic separation scheme to prepare to enter NYC harbor for liberty
2.	Operate CG at safe speed
3.	Overtake vessel in restricted visibility
4.	Sound appropriate sound signals
5.	Avoid risk of collision
6	Take action as give-way vessel
7	Enter a traffic separation scheme

After completing scenario 1, the participants were informed that the ship was underway from anchor on a course of 330 degrees true and with an ordered

speed of 30 knots. The CG would enter the fog layer in one minute based on researcher design. While entering the fog layer, the participants would pass the towing vessels from scenario 1 along their portside. Upon exiting the fog bank, a sailing vessel would either be on the CG's port or starboard bow depending upon if they took action to reduce the CG's speed after entering the fog bank. The closest point of approach (CPA) of the sailing vessel would be less than 300 yards whether action was taken or not. After this situation, the participants encountered a fishing vessel off their starboard bow. The CPA with this vessel was designed to be less than 1000 yards. The participants would then need to alter their course to port to proceed to the traffic separation scheme following the fishing vessel encounter. Upon entering the traffic separation scheme, the scenario was stopped and the participants were debriefed on the scenario.

B. PILOT STUDY GROUP: TREATMENT SESSION 2

Treatment session two consisted of one scenario with a scheduled time to complete this session of 60 minutes. It took the participants approximately 90 minutes to complete this session due to the request of researcher assistance from the participants. Required interaction of the researcher when the participants' decision was inappropriate for the situation contributed slightly to an increase in time. This type of interaction occurred only in the middle of the scenario. A total of 38 entities were utilized with associated geography for these scenarios. Appendix G lists all the entities used in this scenario. The following paragraph summarizes scenario 1 of this treatment session.

1. Treatment Session 2, Scenario 1

Scenario 1 consisted of 34 entities, one high fidelity and 33 low fidelity entities. The participants were placed onboard a CG that was underway on a course of 295 degrees true with an ordered speed of 15 knots inbound to New York City Harbor via Ambrose Channel. The starting point of the CG was 040.27.00 North Latitude and 073.48.63 West Longitude. The simulator time for this scenario was 21:17 (night time) and had a run time of 60 minutes. The

environmental conditions were clear with a visibility of 13 nautical miles. Table 7 summarizes the objectives that were to be completed by the participants in this scenario.

Table 7. Treatment Session 2, Scenario 1 Objectives

Objectives	
1.	Navigate in an international and inland narrow channel
2.	Take action in crossing situation
3.	Take action in an over-taking situation
4.	Take action in a head-on situation
5.	Take action as give-way vessel
6.	Avoid risk of collision

When the simulator was placed in “run,” the CG in which the participants were on began to move on its course. Figure 12 provides an overview of the initial conditions with surrounding vessels and navigation aids while inbound to New York City. The participants were given a few minutes to gain situational awareness before they needed to take action in accordance with the RoR. As the participants proceeded, the researchers labeled the navigational demarcation line with three smoke floats so that the participants were aware that the Inland Navigation Rules now applied in the scenario. The VMS also displayed this information; however, the focus of the study was the application of the RoR rather than electronic chart display knowledge.

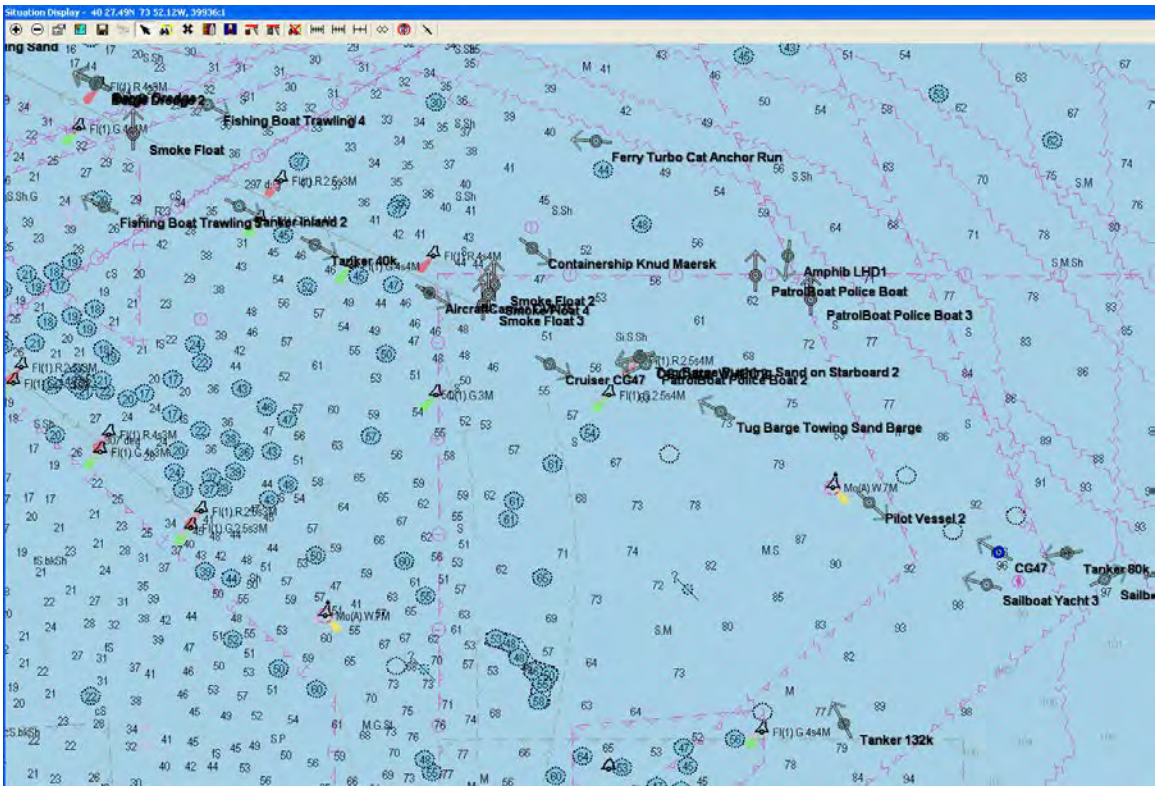

Figure 12. Pilot Study Group: Treatment Session 2, Scenario 1

The participants were exposed to different situations that correspond to the objectives listed in Table 7 and different vessels that were represented in Treatment Session 1, Scenario 1. The researcher had to intervene several times because the participants did not observe the rules or understand how to apply them in that situation. Those interventions were not compiled nor were individual screen captures of those situations saved; however, FMB is capable of conducting such screen captures.

C. PILOT STUDY GROUP: TREATMENT SESSION THREE

Treatment session three consisted of two scenarios with a scheduled time to complete this session of 60 minutes. It took the participants approximately 120 minutes to complete this session due to the request of researcher assistance. The second scenario was the most advanced in design, implementation, and required actions of the participants when compared to all

other treatment session scenarios of the pilot test group. A total of 48 entities were utilized with associated geography for these scenarios. Appendix H lists all the entities used in this scenario. The following paragraphs summarize the scenarios of this treatment session.

1. Treatment Session 3, Scenario 1

Scenario 1 consisted of 19 low fidelity entities. The participants were placed onboard a USN Seahawk helicopter at a starting point of 040.20.54 north latitude and 073.34.30 west longitude. The simulator time for this scenario was 20:08 (30 minutes before sunset) and had a run time of 15 minutes. The environmental conditions were clear with a visibility of 13 nautical miles. Table 8 summarizes the objectives that were to be completed by the participants in this scenario.

Table 8. Treatment Session 3, Scenario 1

Objectives	
1.	Observe the different light configurations, sound signals, and lengths of vessels from the view of a helicopter

When the scenario was placed in run, the helicopter began to move on a pre-planned course, speed, and altitude utilizing different waypoints. Significant effort was made to show the participants every vessel in Part C of Commandant Instruction M16672.2D in this scenario. Ultimately, the scenario was limited to only 18 vessels because the VShip library did not have all of the entities listed in Commandant Instruction M16672.2D (refer to Figure 13). While this scenario was in run, the researcher was in the FMB simulator and answered any questions the participants had regarding the vessels they were observing. Upon completion of the scenario, some of the participants asked if they could look at the different towing vessels again from a different angle. The researcher moved the helicopter to that set of vessels, adjusted its altitude, speed, and view. No waypoints were used in this particular instance, and the researcher maneuvered

the helicopter from Problem Control. Once the participants were confident in their ability to identify different vessels, they moved on to scenario 2.

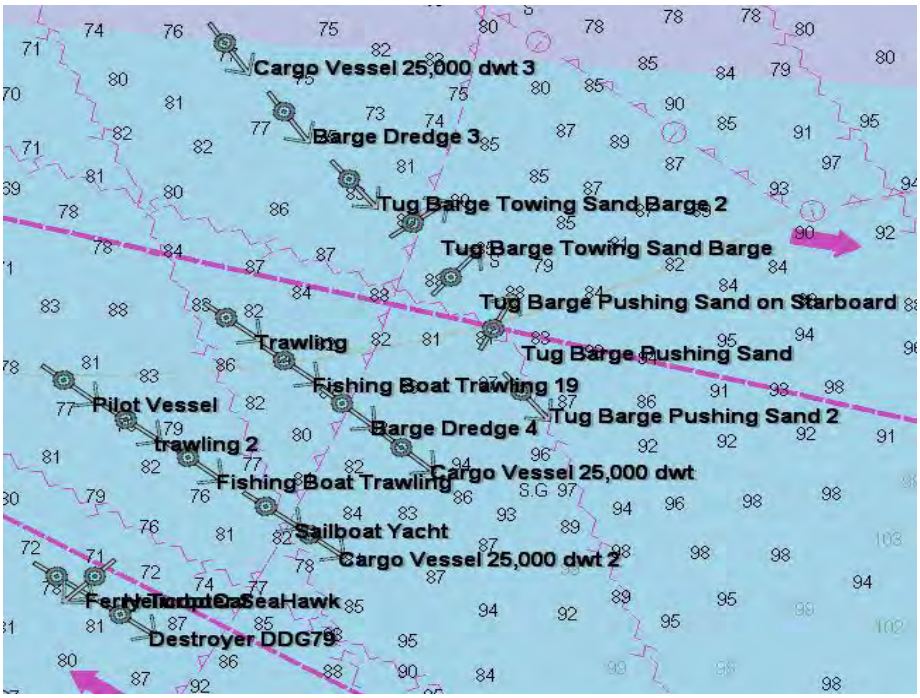

Figure 13. Pilot Study Group: Treatment Session 3, Scenario 1

2. Treatment Session 3, Scenario 2

Scenario 2 consisted of 31 entities, one high fidelity and 30 low fidelity entities. The participants remained onboard the *USN Seahawk* helicopter and were moved to 040.20.54 north latitude and 073.34.30 west longitude. The CG that they would later be placed on was located directly under the helicopter. The simulator time for this scenario was 21:19 (night time) and had a run time of 45 minutes. The environmental conditions were initially clear with a visibility of 13 nautical miles. These conditions would vary throughout the scenario. Table 9 summarizes the objectives that were to be completed by the participants in this scenario.

Table 9. Treatment Session 3, Scenario 2 Objectives

Objectives	
1.	Navigate in an international and inland narrow channel
2.	Take action in crossing situation
3.	Take action in an over-taking situation
4.	Take action in a head-on situation
5.	Take action as give-way vessel
6.	Avoid risk of collision
7.	Navigate in restricted visibility

Once the participants were ready for the scenario to convene, the researcher informed them the scenario was in pause so they could gain situational awareness (refer to Figure 14). The participants had the opportunity to observe some of the vessels they would encounter, visual adjustment to the simulator since it was a night time environment, and radar setup since they were informed about having degraded weather in the scenario. The researcher gave the participants approximately five minutes prior to starting the scenario.

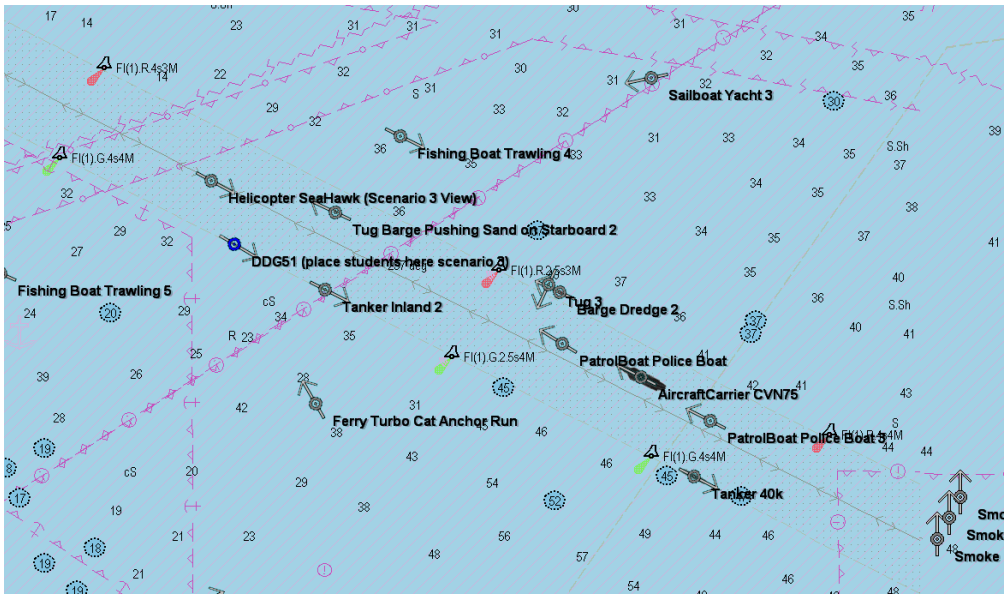

Figure 14. Pilot Study Group: Treatment Session 3, Scenario 2

The participants were placed on the CG once the scenario started. The CG was headed outbound of Ambrose Channel on an initial course of 117

degrees true at 18 knots with a start point of 040.30.21 north latitude and 073.57.65 west longitude. Towards the later part of the scenario, the environment was changed in slight increments to give the effect of an incoming storm. Table 10 summarizes the objectives that were to be completed by the participants in this scenario.

Table 10. Treatment Session 3, Scenario 2 Global Environment Settings

Type of Visibility	Storm
Visibility Range	13 nautical miles to 500 yards -Range decremented by 1 nautical mile every 15 seconds until 1 nautical mile remained. -Range decremented by 100 yards every 15 seconds until 500 yards remained.

This provided the participants with a more robust storm and a decrease in visibility that was apparent visually and on radar. To accomplish this, the researcher unselected and re-selected “override” under “type of visibility,” which created lightning effects and thunder sounds for each decrement in visibility in the simulator. When visibility reached one nautical mile, it became readily apparent that all the participants began to rely on the radar and sound signals. As the range continued to decrease, they nearly collided with a vessel because they forgot to keep looking forward. The radar started to become useless because the participants failed to change their radar range and settings; this would have decreased the amount of clutter on the radar screen that was being generated from the storm. They avoided collisions by making a large speed change and altering their course once they observed the lights of the other vessel that was directly ahead of them with a port beam aspect. This concluded the FMB treatment sessions and the researcher answered any questions the participants had regarding this session.

D. PILOT STUDY GROUP FEEDBACK

Some of the participants provided some written, but mostly verbal feedback regarding the study. Some of the participants stated that the time was

appropriate for the sessions and participation would be greater if the study could be conducted in the day rather than evening. All of the participants thought the helicopter view in treatment session 3 was better than treatment session 1 and recommended that be used in the future. They were amazed that their counterparts did not take advantage of this opportunity. After participating in these sessions; all the participants stated that they understood the applicability of the rules rather than the memorization of them. After their official 50 question SWOS RoR exam, the participants provided unsolicited exam scores. The average of these scores was 95.33 percent, with two of the six participants scoring 98 percent, and no participants scored below 92 percent.

E. EXPERIMENTAL STUDY GROUP: TREATMENT SESSION

As previously discussed in Chapter III, all preliminary administrative documents and FMB familiarization were conducted in this session. This treatment session consisted of three scenarios with a scheduled time to complete this session of 90 minutes. It took the participants approximately 120 minutes to complete this session. A total of 59 entities were utilized with associated geography for these scenarios. Appendix H list all the entities used in this scenario. The following paragraphs summarize the scenarios of this treatment session.

1. Treatment Session, Scenario 1

Scenario 1 consisted of 22 low fidelity entities. The participants were placed onboard a USN Seahawk helicopter at a starting point of 040.18.38 North Latitude and 073.27.89 West Longitude. The simulator time for this scenario was 20:00 (30 minutes before sunset) and had a run time of 12 minutes. The environmental conditions were clear with a visibility of 13 nautical miles. The same objectives and procedures in the pilot study group treatment session 3, scenario 1 were conducted in this scenario. An additional nine low fidelity entities were included in this scenario after reconfiguring existing entities in VShip (refer to Figure 15). The decision to attempt to manipulate VShip's

existing entities was based upon the participant's feedback from the pilot study group and SWOS instructors who reviewed the design of that scenario. Additionally, the helicopter track was changed to a single line rather than parallel. No software or coding changes were saved in the VShip software or its library.

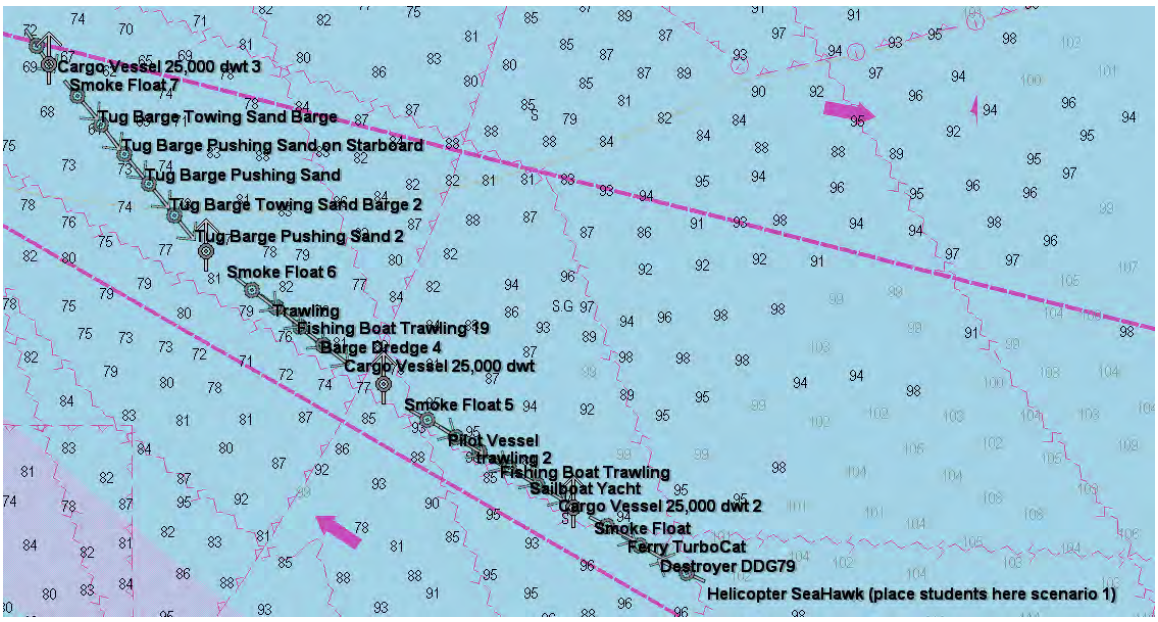

Figure 15. Experimental Study Group: Treatment Session, Scenario 1

2. Treatment Session, Scenario 2

Scenario 2 consisted of eight entities, one high fidelity entity and seven low fidelity entities. The participants were placed on a DDG and were moved to 040.10.88 North Latitude and 72.43.05 West Longitude. The simulator time for this scenario was 20:12 (18 minutes before sunset) and had a run time of 15 minutes. The environmental conditions were clear with a visibility of 13 nautical miles. In the pilot study, participants took advantage of the steering and propulsion characteristics of the ship to avoid collision when their indecisiveness or inappropriate decisions created such an *in extremis* situation. As a result, for this scenario, the DDG was limited to one functional rudder and a speed of 15 knots to prevent the subjects from using the ship's normal maneuverability to

evade the consequences of their errors. Table 11 summarizes the objectives that were to be completed by the participants in this scenario.

Table 11. Treatment Session, Scenario 2 Objectives

Objectives	
1.	Take action in crossing situation
2.	Take action in an over-taking situation
3.	Take action in a head-on situation
4.	Take action as give-way vessel
5.	Avoid risk of collision

The participants were given approximately five minutes to gain situational awareness before the scenario was placed in run (refer to Figure 16). Once the scenario commenced, the researcher maneuvered the low fidelity objects to create situations that exercised all of the objectives. Researchers had to intervene with all the groups for the following objectives: crossing situation; action as give-way vessel; action as stand-on vessel; and avoiding risk of collision. After debriefing the participants on the mistakes they made for each situation, the error was not made any further in this scenario.

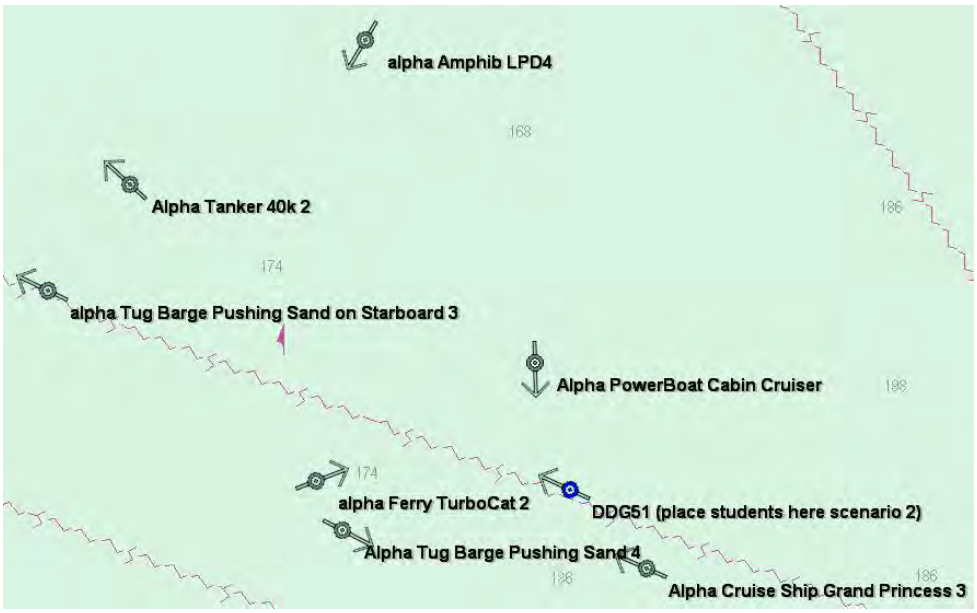

Figure 16. Experimental Study Group: Treatment Session, Scenario 2

3. Treatment Session, Scenario 3

Scenario 3 consisted of the same objectives and procedures as the pilot study group. The pilot study group and all groups in the experimental study behaved similarly in the later part of the scenario with respects to radar management and maintaining a proper lookout. Figure 17 shows the initial conditions of the simulation.

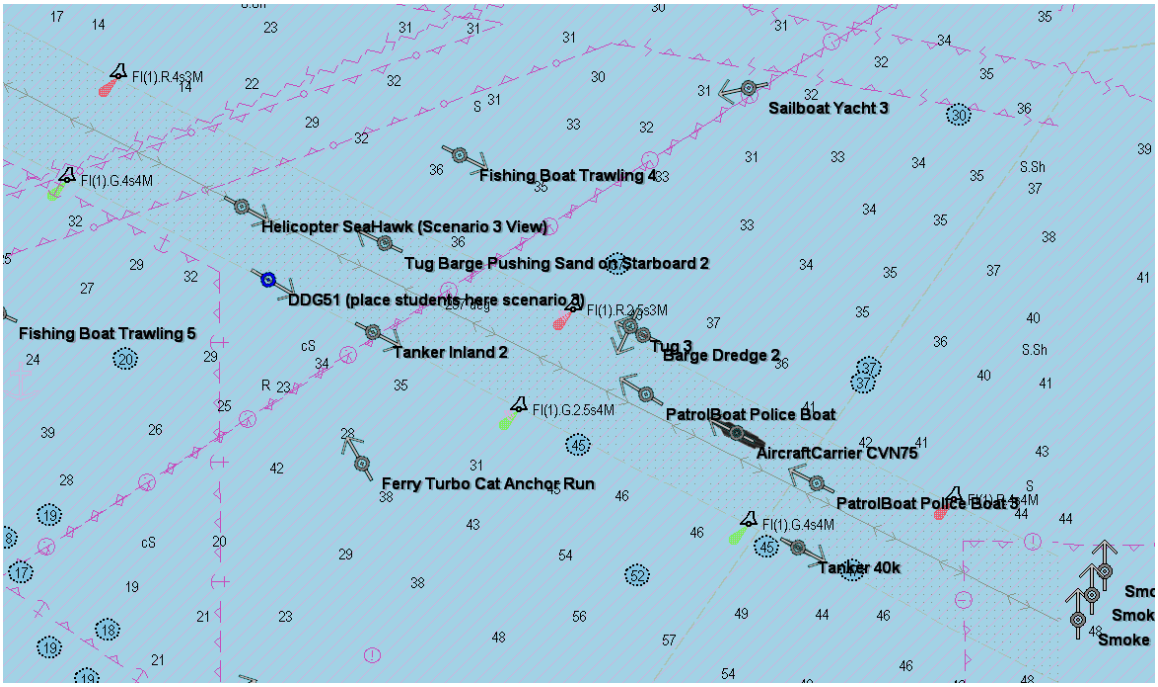

Figure 17. Experimental Study Group: Treatment Session, Scenario 3

F. EXPERIMENTAL STUDY GROUP FEEDBACK

None of the participants provided additional feedback other than the post-questionnaire. The majority of the participants stated verbally that the simulator favorably contributed to their understanding of the application of the RoR. Additionally, they stated that this type of session should be used in conjunction with the RoR lecture to emphasize the material discussed in class.

G. PILOT AND EXPERIMENTAL STUDY GROUP: POST-TREATMENT SESSION

All participants completed RoR post-study test and post-questionnaire in this session (refer to Appendices C–E). The scheduled time to complete this session was 60 minutes with the majority of the participants completing this session within 45 minutes. Results of the RoR post-test and post-questionnaire are summarized in Chapter V.

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V. RESULTS

A. DATA PREPARATION AND STATISTICAL ANALYSES

This study consisted of participants enrolled in the ASAT course in SWOS Newport. Twenty-seven participants served in the treatment group and 341 previous ASAT students' practice RoR test scores were used for the control group. For the treatment group, the demographic survey and post-questionnaire data was conducted on paper and recorded in the JMP Pro Version 10 (JMP 10) statistical analysis software program. The data was analyzed utilizing summary statistics, one-way t-tests, and the Fisher's Exact Test in JMP 10. For the control group, no demographic information was available; however, occupation and rank of participants, timeframe of training, and length in the Navy is approximately the same for all groups. Tables 12-13 summarize general demographics and shipboard experience for the pilot and experimental study groups.

Table 12. General Statistics from Participants' Demographic Surveys

Demographic Survey (General)	Pilot	Experimental
Commissioning Source		
USNA	3	5
USCGA	0	1
NROTC	2	5
OCS	1	10
Time Onboard Ship Months		
12 – 18	6	16
Greater than 18	0	5
RoR Test Administration Onboard Ship		
Every 6 months	1	1
Ever y 5 months	1	0
Every 3 months	1	10
Every 2 months	0	1
Every month	2	7
Never	0	1

Demographic Survey (General)	Pilot	Experimental
Previous Ship-handling Simulator Exposure		
Yes	**5**	**21**
Mean (Number of Times)	**5.2**	**5.30**
Standard Deviation (Number of Times)	**2.86**	**3.23**
No	**1**	**0**
Previous Ship-handling Simulator Exposure With Emphasis on RoR		
Yes	**0**	**3**
No	**6**	**18**
Simulation Technology is an Effective Tool for Training (7 = Strongly Agree and 1 = Strongly Disagree)		
Median	**5.5**	**6**
Mode	**5**	**6**

There were no statistically significant differences in the general demographics of the pilot and experimental study groups.

Table 13. Shipboard Experience from Participants' Demographic Surveys

Demographic Survey (Shipboard Experience)	Pilot	Experimental
Officer Of The Deck Qualified		
Yes	**6**	**16**
Mean (Months)	**1.18**	**4.45**
Standard Deviation	**0.84**	**8.89**
No	**0**	**5**
Deployed Overseas		
Yes	**4**	**19**
Mean (Months)	**6.88**	**9.61**
Standard Deviation	**0.63**	**5.53**
No	**2**	**2**
Officer of the Deck Qualified on Deployment		
Yes	**1**	**8**
No	**1**	**10**

There were no statistically significant differences in the general demographics of the pilot and experimental study groups.

B. ANALYSIS OF PRACTICE RULES OF THE ROAD TEST

The SWOS RoR practice test for ASAT students contains 30 questions that cover the majority of the RoR. SWOS Newport allows its students to take a RoR practice test prior to the recorded test that is used as part of their overall grade point average. This practice test provides the students with the opportunity to see which rule(s) they must focus on or need further clarification from an instructor prior to the administration of this test. Appendix D shows a representation of these questions that are administered to the ASAT students.

A pre- and post-study RoR practice test was presented to the pilot study group, and a post-study RoR practice test to the experimental group. In the pilot study group, their test differed from the experimental and control groups; as a result, the control group's RoR practice test scores were utilized for the hypothesized mean when conducting the data analysis between those groups. The control group's RoR practice test was administered as the RoR post-study test for the experimental study group so that data analysis could be conducted between those two groups.

1. Control Group RoR Results

The RoR practice test for the 341 ASAT students in the control group was not administered by the research team. Under SWOS Newport permission and instructor supervision, the research team obtained the results from the Perception database that maintains records of every test conducted with the Perception test bank. On the RoR practice test administered to the control group by SWOS Newport instructors, 337 of the 341 (97.94 percent) students scored below a 90 percent after having completed the RoR lectures. Even though our demographic survey summary statistics represented that most ships administer a RoR test at least quarterly, there is statistically significant evidence (t(340)=-

37.734, p<.0001) to suggest that the students are not retaining this knowledge through the ship's testing standards as shown in Figure 18 or from the RoR lectures at SWOS Newport.

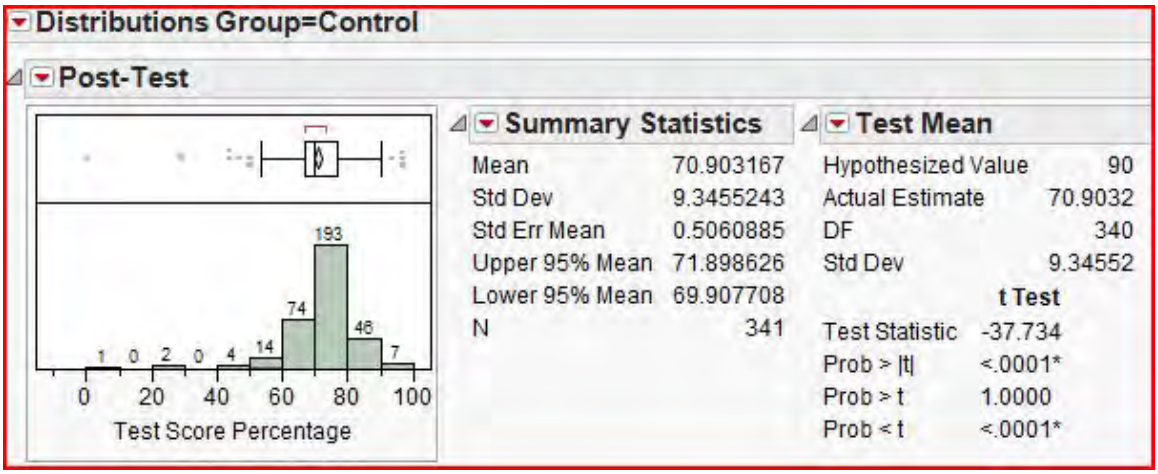

Figure 18. ASAT Practice RoR Test Summary Statistics

After observing the *Test Analysis Report* produced by perception (refer to Appendix D), the research team concluded from their analysis that the simulator scenarios needed to focus on the following: risk of collision situations; vessel lighting configurations; and sound signals.

2. Pilot Study Group RoR Results

The pilot study group was administered a RoR pre- and post-study test. The pre-test was administered to determine if this group would perform similarly to the control group. The pre-test was not the same as the one administered to the control group; however, it contained similar questions. In addition, it provided useful knowledge in test implementation and students' knowledge base since there was no exposure to the control group.

Five of the six participants in this group were administered the pre-test. The participant who did not take the test was exposed to several minutes of the first simulator session because they arrived late to this session. Utilizing one-

sample t-test, Figure 19 shows there were no statistically significant (t(4)=0.91, p>0.42) differences between the pilot study and control groups' RoR scores based on a two tailed alpha level of 0.05.

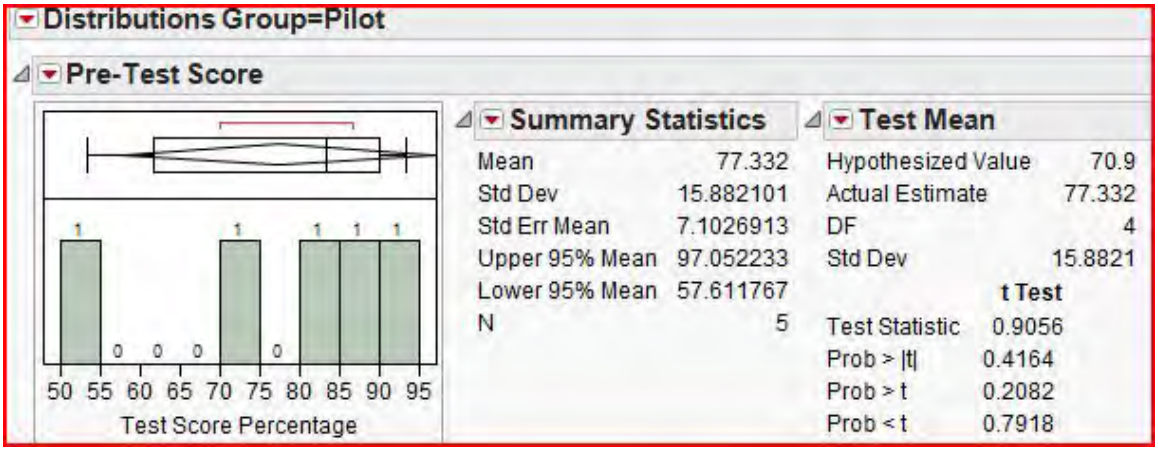

Figure 19. Pre-Test, Pilot Study Group Versus Control Group

After the pilot study group concluded their treatment sessions, a RoR post-study test was administered that consisted of similar questions administered to the control group. From this analysis, based on a sample size of six, the research team is 95 percent confident that the true population mean of the test result is between 90.35 and 96.31 grade points if simulation technology is included in the RoR lectures. As this confidence interval is above 90 percent— and the post-test mean (93.33) is well above the pre-test mean (77.33)— the results indicated that additional testing needed to be conducted with a larger sample size to ensure validity of the study that was conducted with the pilot study group. Utilizing one-sample t-test, the analysis showed statistically significant differences between the pilot and control group; the pilot group had higher mean test scores than the control group (t(5)=18.42, p<.0001) as shown in Figure 20. The reasoning for conducting a one-sample t-test for this analysis was that the control group's mean test score was hypothesized, normally distributed, population sample independent of each other, and the sample size of the pilot group was small.

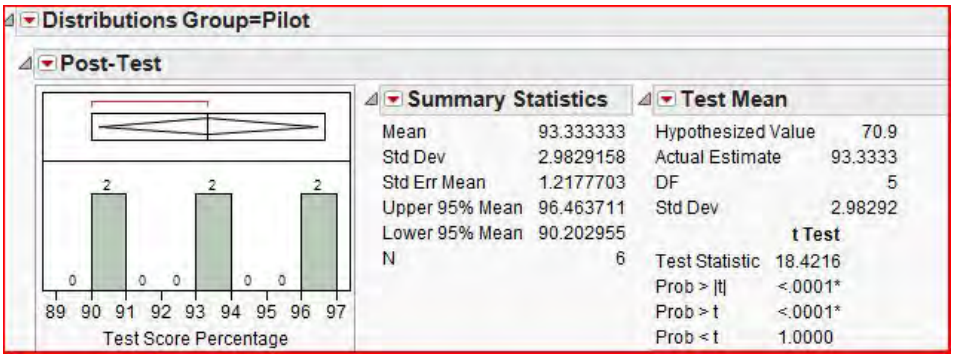

Figure 20. Post-Test, Pilot Versus Control Group RoR Practice Test

At the time of the study, a detailed analysis of the questions the participants missed on the post-study RoR practice test was not conducted because of the small sample size, high scores, and the RoR test differed from that of the control group. A different RoR test was used in the pilot study because there was limited knowledge and access to the Perception database. When reviewing with the participants the post-study RoR practice test, the research team discovered that the participants missed questions pertaining to collision situations, vessel configuration lights, and sound signals. Based on their subjective feedback and overall results from the study, the study and scenarios was redesigned for the follow-on study.

3. Experimental Study RoR Results

No pre-study RoR practice test was administered to the experimental study group because the treatment sessions convened two to three days after the RoR lecture series. Based on the feedback from the pilot study, amount of volunteers in the pilot study, and RoR practice scores from the pilot study and control groups, the research team hypothesized that the pre-study RoR practice test data would not be statistically significant with this group. The post-study RoR practice test was administered in the same manner as in the pilot study group; however, the exact same test that was administered to the control group was utilized. From this analysis, based on a sample size of 21, the research team is 95 percent confident that the true population mean of the test result is

between 84.88 and 98.29 grade points if simulation technology is included in the RoR curriculum. More importantly, the findings show statistically significant differences between the experimental and control group, in which the experimental group had higher mean test scores than the control group (t(360)=9.98, p<.0001) as shown in Figure 21.

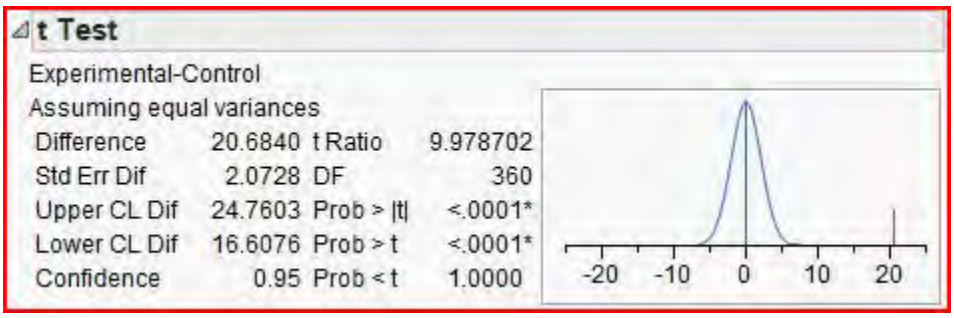

Figure 21. Post-Test, Experimental Versus Control Group RoR Practice Test

In the second analysis, a one-sample t-test was conducted between the pilot study and experimental study groups to determine if the two groups had a significant difference in their test score. There were no statistically significant differences between the two groups in this analysis (t(20)=-1.19, p=0.25), as shown in Figure 22. Based on these consistent results, the researchers concluded that simulation technology will increase a student's RoR test score if incorporated in the curriculum.

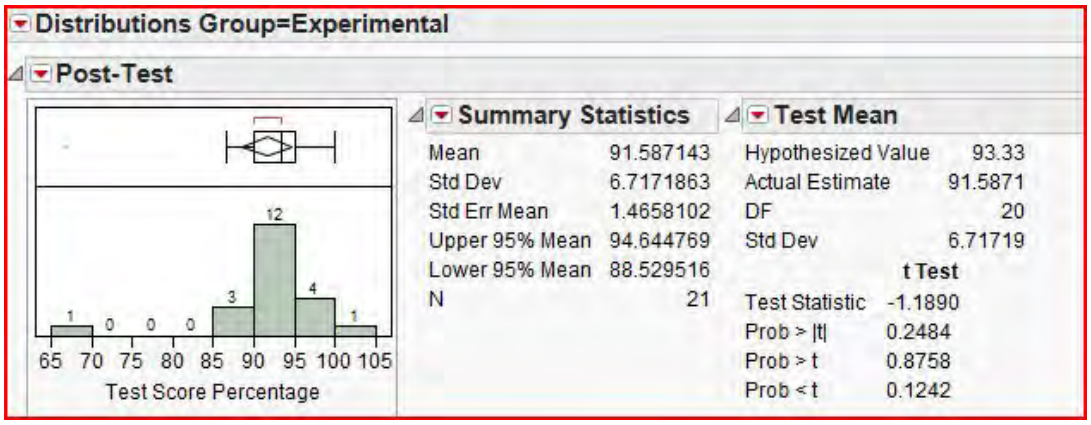

Figure 22. Post-Test, Experimental Study Versus Pilot Study Group

Unlike the pilot study, a detailed statistical analysis was conducted on the questions missed by the experimental group. Prior to conducting that analysis, the research team determined that only the questions whose mean score was less than a 90 percent on the control group data set would be compared to that of the experimental group. Implementing this type of analysis allowed the research team to perform a one-sample t-test on those questions. Table 14 summarizes the t-test and Appendix O provides a detailed graphical representation of this data. Of note, only rules 8, 24, 26, 28, and 34 were not statistically significant. For all tests, the degrees of freedom were 20.

Table 14. Experimental and Control Group Missed RoR Areas

Rule Number	Experiment Group Mean (sd)	Control Group Mean (sd)	One-Sample T-test Statistics	p-value
8	90.48 (30.08)	85.00 (30.08)	0.83	= 0.4140
21	66.67 (24.15)	53.50 (24.15)	2.49	= 0.0213
23	71.43 (46.29)	45.00 (46.29)	2.5173	= 0.0205
24	76.35 (43.35)	62.00 (43.45)	1.52	= 0.1450
26	81.05 (40.03)	75.50 (40.03)	0.64	= 0.5326
27	97.62 (10.91)	78.50 (10.91)	8.03	< 0.0001
28	95.23 (21.82)	88.00 (21.82)	1.52	= 0.1442
29	71.42 (46.29)	46.00 (46.29)	2.52	= 0.0205
34	85.71 (35.85)	84.00 (35.86)	0.22	= 0.8288
35	95.24 (21.82)	79.00 (21.82)	3.41	= 0.0028
36	95.24 (21.82)	69.00 (21.82)	5.51	< 0.0001

C. ANALYSIS OF POST-STUDY QUESTIONNAIRE

The pilot and experimental study groups were provided a post-study questionnaire after the completion of all treatment sessions and post-study RoR practice test. All six of the pilot and 21 of the experimental study participants completed the post-study questionnaire and provided valuable feedback to the researchers for follow-on studies. The questionnaire consisted of 10 questions; each question was based on a Likert-scale (refer to Appendix E). With the exception of the stress level question, all questions ranged from one to seven, with one indicating strong disagreement and seven indicating strong agreement.

In evaluating this data, a Fisher Exact Test was conducted to analyze the median between these two groups because the responses are considered nonparametric and the sample size was not large. In addition, because of the similarities in the results between the pilot and experimental groups, the post-study questionnaire results are summarized as one set (n=27) of data unless large differences were discovered between the groups, which would then be reported separately.

1. Response to Stress Level of Study

Figures 23–26 show the participants' responses to the stress they experienced in the simulator during the treatment sessions. The researchers observed a large difference between the medians of the pilot and experimental study groups in this analysis. Despite this difference, the Fisher's Exact Test in Figure 26 showed no statistically significant differences in the stress level between these groups (n(27), p>0.18).

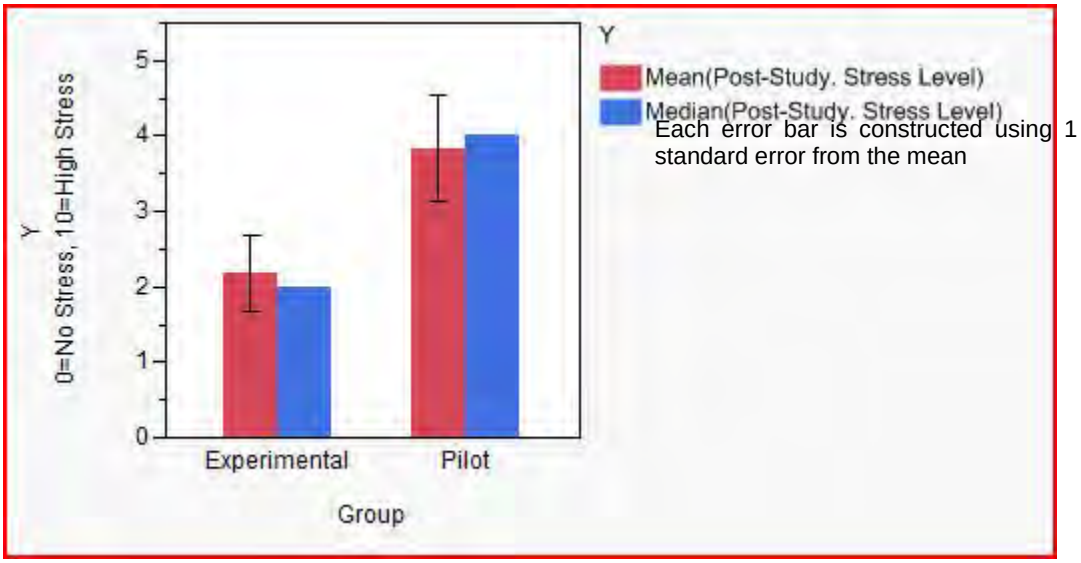

Figure 23. Mean and Median of Stress Level, Experimental Study and Pilot Study Groups

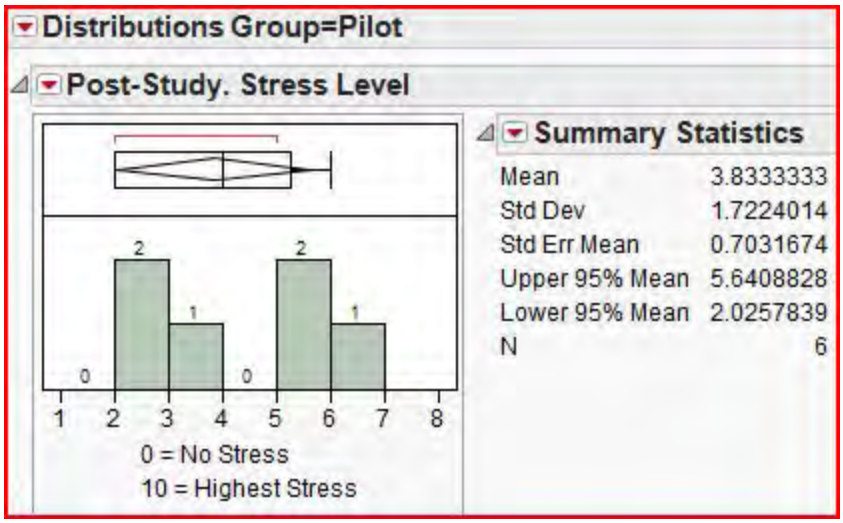

Figure 24. Stress Level of Pilot Study Group

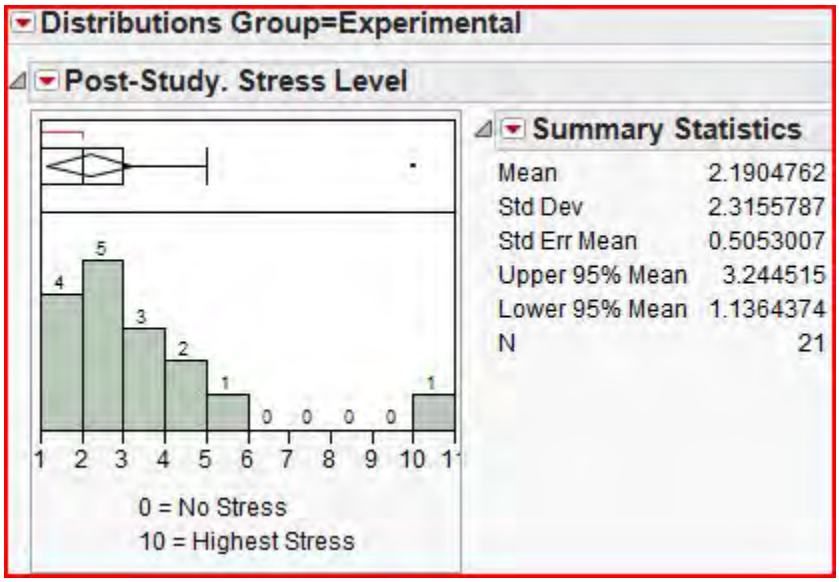

Figure 25. Stress Level of Experimental Study Group

Tests

N	DF	-LogLike	RSquare (U)
27	7	5.9552972	0.1155

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	11.911	0.1035
Pearson	10.538	0.1601

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Warning: Average cell count less than 5, LR ChiSquare suspect.

Fisher's Exact Test	Table Probability (P)	Two-sided Prob ≤ P
	0.000851	0.1848

Figure 26. Fisher's Exact Test for Stress Level

2. Response to Question One: I Feel That the Sessions Were Realistic and Contributed to My RoR Knowledge

Figure 27 shows the participants' responses to whether the sessions were realistic and contributed to the participants' RoR knowledge. Twenty-three of 27 participants agreed that the sessions were realistic and contributed to their RoR knowledge, with 12 of 27 strongly agreeing to that statement. Three of 27 participants remained neutral on the statement.

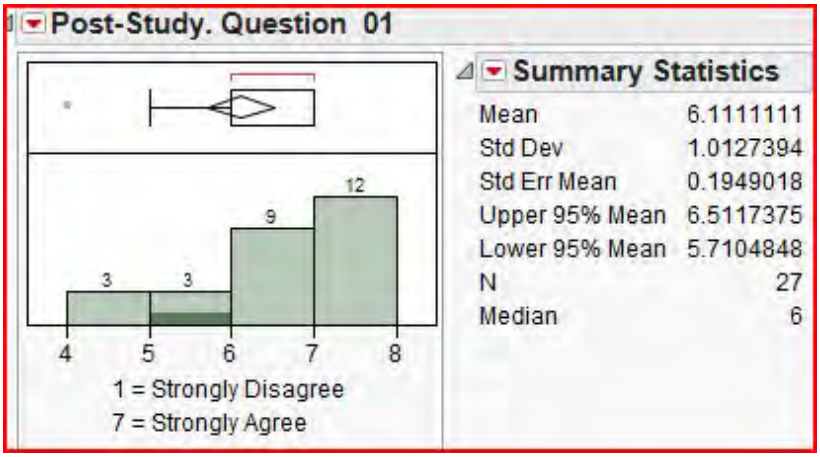

Figure 27. Realism of Sessions

3. Response to Question Two: I Felt That I Was Able to Safely Navigate the Ship in Each Session

Figure 28 shows the participants' responses to whether they felt they were able to safely navigate the ship in each session. All participants agreed that they felt able to safely navigate the ship in each session, with nine of 27 strongly agreeing to that statement. Eight of 27 participants remained neutral on the statement.

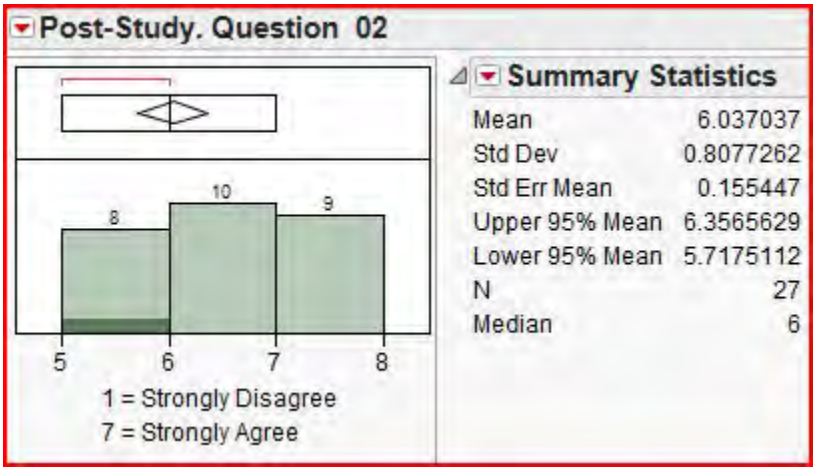

Figure 28. Ability To Safely Navigate The Ship

4. Response to Question Three: Utilizing the Radar Helped Me with My Navigation

Figure 29 shows the participants' responses to whether or not the radar assisted them with navigation. Twenty of 27 participants agreed that the radar assisted them, with 10 of 27 strongly agreeing to that statement and six of 27 participants remaining neutral on the statement.

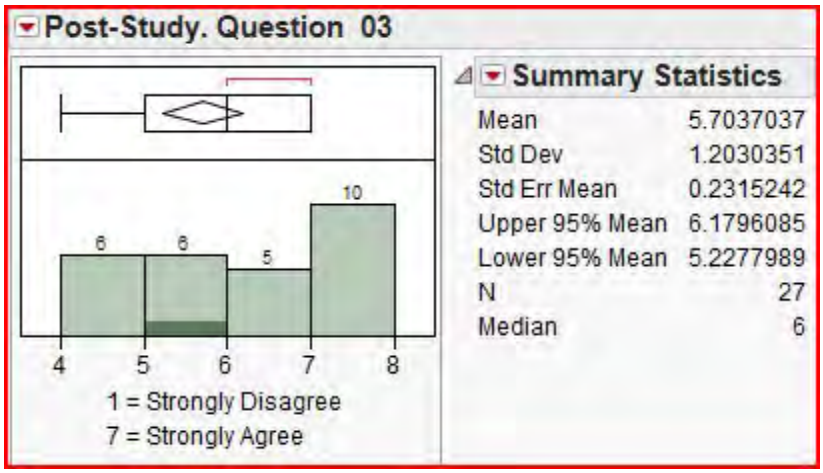

Figure 29. Radar Utility

5. Response to Question Four: Utilizing VMS Helped Me with My Navigation

Figure 30 shows the participants' responses to whether the VMS assisted them with navigation. Fifteen of 27 participants agreed that the VMS assisted them, with five of 27 strongly agreeing to that statement and four of 27 disagreeing.

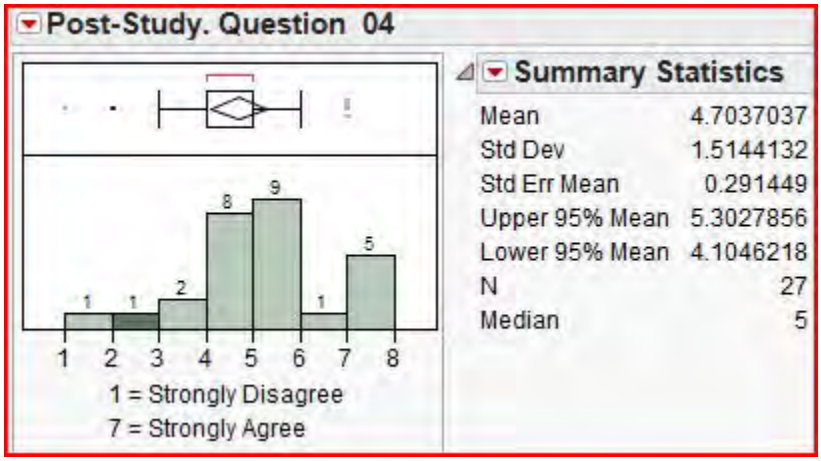

Figure 30. VMS Utility

6. Response to Question Five: Auditory and Visual Simulation Enhanced the Training Session and Contributed to My Learning

Figure 31 shows the participants' responses to whether the auditory and visual simulation enhanced the sessions and contributed to their learning. Twenty-three of 27 participants agreed that auditory and visual simulation contributed to their learning, with 11 of 27 strongly agreeing to that statement and two of 27 participants remaining neutral.

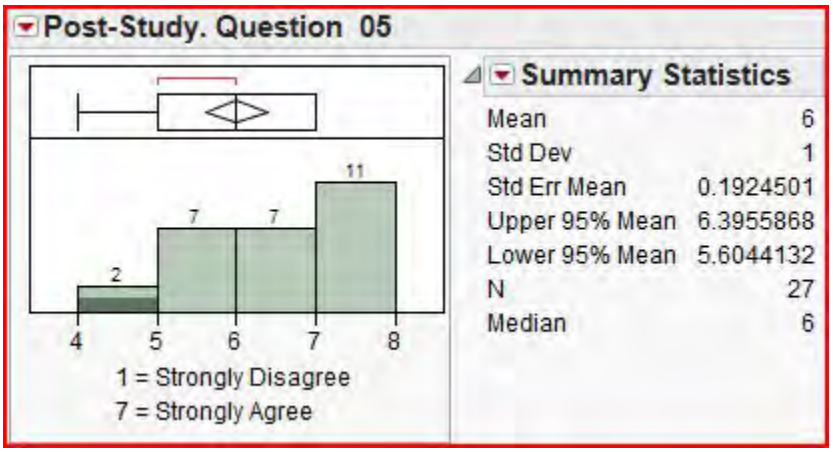

Figure 31. Contribution of Auditory and Visual Simulation to Learning

7. Response to Question Six: In Comparison with *USCG Navigation Rules for International and Inland Waters* Book, FMB was More Effective in Learning Maneuvering Schemes, Lights, and Sound Signals

Figure 32 shows the participants' responses to whether the FMB was a more effective tool for learning maneuvering schemes, lights, and sound signals than the *USCG Navigation Rule* book (Commandant Instruction M16672.2D). Twenty-three of 27 participants agreed that the FMB was more effective, with 10 of 27 strongly agreeing to that statement and two of 27 participants not agreeing. One of 27 participants strongly disagreed and can be considered an outlier

based on the interaction with the researchers in respect to this question. The participant stated to the researchers that because of their loyalty to the USCG that they would not agree with this statement.

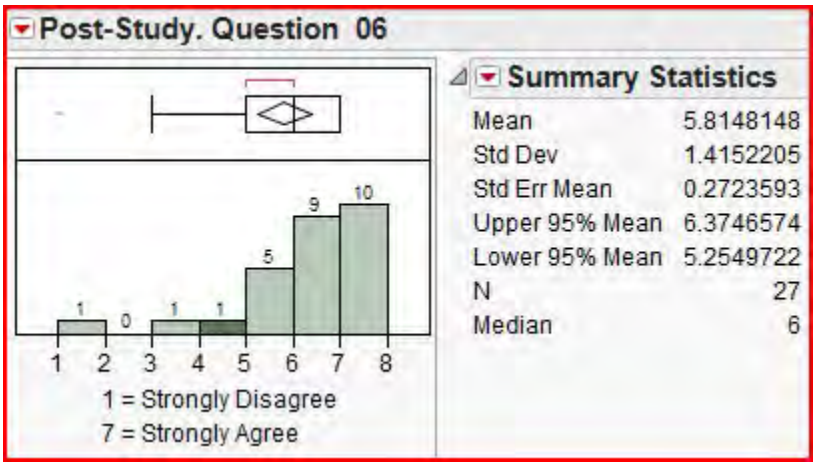

Figure 32. Effectiveness of FMB Compared to USCG Navigation Rules Book

8. Response to Question Seven: I Feel That Auditory and Visual Simulation Technology Should be Incorporated in instructing USCG Navigation Rules

Figure 33 shows the participants' responses to whether the auditory and visual simulation technology should be incorporated into RoR instruction. All 27 participants agreed that the RoR course should use auditory and visual simulation technology.

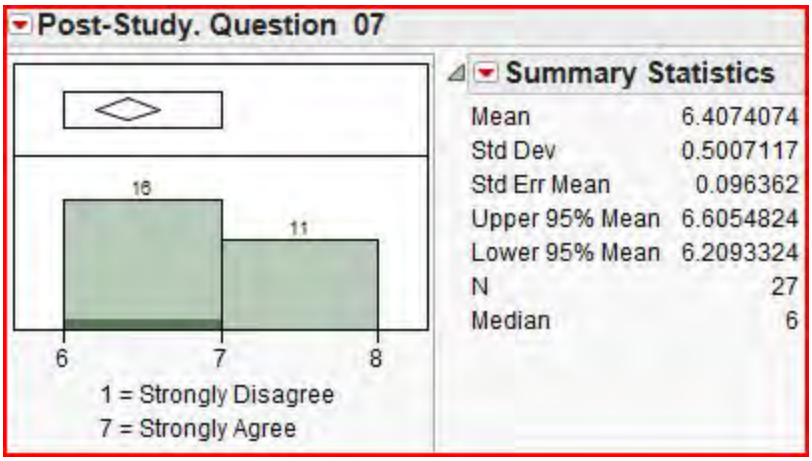

Figure 33. Incorporation of Auditory and Visual Simulation in Instructing USCG Navigation Rules

9. Response to Question Eight: I Feel More Prepared to Take a RoR Exam after Completing These Sessions in Respects to Maneuvering Schemes, Lights, and Sound Signals

Figure 34 shows the participants' responses to whether the sessions prepared them for the RoR test. All 27 participants agreed that these sessions prepared them for the RoR test.

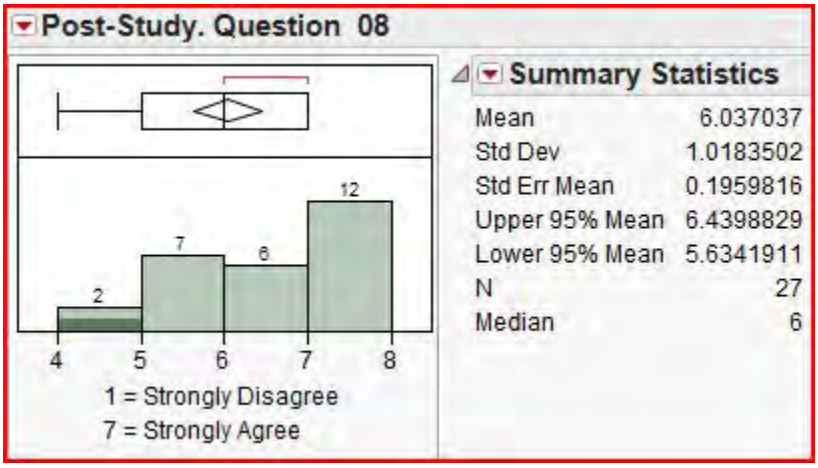

Figure 34. Preparedness for RoR Exam After Completion of Treatment Sessions

10. Response to Question Nine: I Feel That an interactive Tool Would be Useful in Maintaining RoR Proficiency in the Fleet

Figure 35 shows the participants' responses to whether an interactive tool would be useful in maintaining RoR proficiency in the fleet. Twenty-four of 27 participants agreed that an interactive tool would be useful, with 12 of 27 strongly agreeing to that statement and two of 27 participants remaining neutral.

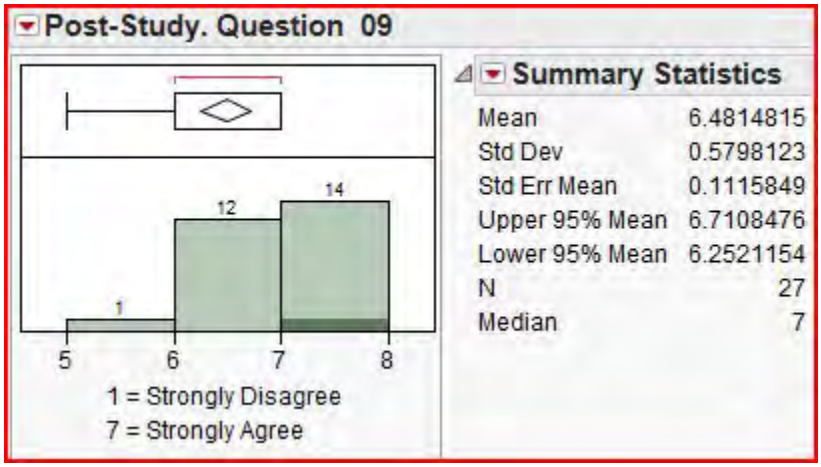

Figure 35. Usefulness of an Interactive Tool for Maintaining RoR Proficiency In the Fleet

Of note, 26 of 27 participants have utilized a ship-handling simulator for ship-handling proficiency, but only three of the 26 participants experienced an emphasis on the RoR while in that ship-handling simulator.

11. Response to Question Ten: If Provided the Opportunity, I Would Use an Interactive Tool to Maintain RoR Proficiency

Figure 36 shows the participants' responses to whether they would use an interactive tool to maintain RoR proficiency. Twenty-seven of 27 participants agreed that they would use an interactive tool to maintain RoR proficiency, with 19 of 27 strongly agreeing to that statement.

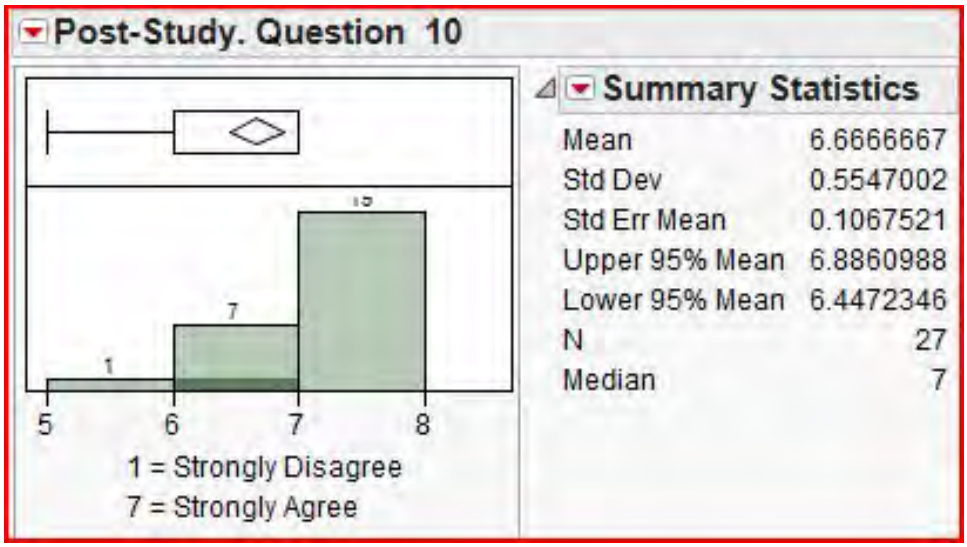

Figure 36. Provided the Opportunity, Participant Would Use Interactive Tool to Maintain RoR Proficiency

VI. SUMMARY, DISCUSSION, RECOMMENDATIONS, AND CONCLUSIONS

A. SUMMARY

This thesis was motivated by the necessity to determine if the current simulation technology in the Navy could be incorporated into teaching lectures that are normally instructed in a classroom environment, specifically with instructing RoR. Utilizing a control group and two study groups, the primary research question addressed in this thesis was: do students who use ship-handling simulator training achieve higher scores on a standardized RoR test than those who do not? The research also examined explanatory questions, which are discussed in this chapter. Overall, the data collection and analysis from this thesis indicates that individuals utilizing a ship-handling simulator with scenarios dedicated to teaching RoR can achieve higher scores on a standardized RoR test than those who did not receive this training.

In order to reach this conclusion, the research team utilized a between-groups study consisting of volunteers from SWOS Newport enrolled in the ASAT course and a data set of 341 individual RoR practice test scores. RoR test scores were the performance measure of this research and explanatory feedback provided additional insight into the study. The control group did not receive any RoR simulator treatment sessions at SWOS Newport prior to taking their RoR practice test while the other two groups did. The treatment sessions in this study consisted of scenarios that were specifically designed to address RoR situations that the participants may have never been exposed to in real life before which contributed significantly to their learning experience in the simulator. After their respective time lapse (approximately 24 hours), the two treatment groups completed a RoR post-study test while the control group completed their RoR practice test one to two days after their last RoR lecture. This study was concluded at the completion of the RoR post-study test and post-questionnaire.

B. HYPOTHESIS DISCUSSION

Null hypothesis (H0): There will be no group differences in the control and treatment groups' standardized RoR practice test scores when RoR ship-handling simulator training is incorporated into the treatment group's RoR lectures.

Alternative hypothesis: The treatment groups who had RoR ship-handling simulator training incorporated with their RoR lectures will achieve higher scores on a standardized RoR test those who did not.

1. Pilot Study Group

The pilot study group significantly improved their RoR practice test score from their pre-study test score to the post-study test score. Moreover, none of these participants received below a 90 percent on their official RoR test when administered by SWOS Newport instructors. This group had only one RoR lecture prior to taking the pre-study test; therefore, the researchers anticipated that the scores would be relatively low based on personal experience and evaluations prior to this study. Even though the sample size was only five for the pre-study test, the researchers did not conceive that their test score would show no significant difference between the control groups who did receive all the RoR lectures. This suggests that either (1) students lacked preparation for the practice test by failing to maintain the knowledge or study, or (2) did not care since it was a practice test. The practice test at SWOS Newport can be challenging for most because this test, in our opinion, is not administered properly in the fleet and students are not prepared for the questions that are asked on the test.

It is important to note that the pilot study group's test score went from a mean score of 77.39 percent to 93.33 percent after the treatment sessions as discussed in Chapter V. The quality of instruction at SWOS with RoR is high according to those who have been instructed there, so the researchers were heavily invested in ensuring that both of the treatment groups were continuing to

receive that high quality training during their treatment sessions. The researchers estimated that treatment sessions with this group would only last 45 minutes based on scenario design. However, because of discussion and additional training points, the researchers observed these sessions lasting anywhere from 90 to 120 minutes.

When comparing the RoR post-study test to that of the control group, the researchers were overwhelmingly surprised that the pilot study group's RoR post-study test would surpass that of the control group's (mean score of 99.33 percent compared to 70.9 percent). There are several factors that may contribute to this finding: (1) additional hands-on training tailored towards highly missed RoR areas on the test, (2) ship-handling simulator training time with RoR specific designed scenarios, (3) smaller student to instructor ratio (26:1 compared to 6:1), and (4) material hand-outs providing visuals and mnemonics summarizing the Commandant Instruction M16672.2D. Unfortunately, the pilot study group did not complete the provided study log given to them that would have allowed the researchers to determine if the material hand-outs contributed to their learning and achieving higher scores; therefore, we can only assume that it may have contributed to their post-study test score.

2. Experimental Study Group

Unlike the pilot study group, the experimental study group only had one treatment session because of the time required to complete the study and feedback from the pilot study. Based on the observations from the pilot study, no pre-study test was administered to this group because the researchers hypothesized that their scores would be the same as the pilot and control groups' scores if one was administered. After conducting the treatment session, the researchers observed similar deltas between the control and experimental study groups' RoR practice test (mean score of 70.9 percent compared to 91.58 percent). Unlike the pilot study group, the experimental study group's RoR post-study test was exactly the same as the control study group's test. There were no

differences in the methodology of administering the scenarios to this group during the treatment session and scenarios were similar to those in the pilot group. Based on these conditions, the researchers observed no significant differences between the pilot and experimental groups' RoR post-study test (mean score of 93.33 percent compared to 91.58 percent).

From the results and analysis of the data collected in this study, the researchers rejected the H0 and accepted the HA: treatment groups who had RoR ship-handling simulator training incorporated with their RoR lectures will achieve higher scores on a standardized RoR test those who did not.

C. EXPLORATORY QUESTIONS DISCUSSION

The researchers utilized 10 exploratory questions, through the use of a post-study questionnaire, to capture subjective measurements for this study. This provided additional insight into the study and allowed the researchers to implement changes in scenario design and provide valuable recommendations for the fleet. The data gathered from the RoR post-study test proved that RoR ship-handling simulator training would increase a RoR test score, but it did not prove how useful the simulator was implicitly. The researchers understood that implicit knowledge is nearly impossible to measure, thus the post-study questionnaire attempted to measure that through the following questions.

1. What was the Highest Level of Stress Experienced by the Participants, "10" Being the Most Stressful to "0" Being the Least?

The researchers observed a difference between the medians of the pilot and experimental study groups in their analysis. They concluded the following possibilities to these differences: the pilot study group had three treatment sessions instead of one; the pilot study group conducted treatment sessions in conjunction with RoR lectures rather than at the conclusion of the RoR lectures; and the experimental group was exposed to another ship-handling simulator

variant during the week of their treatment session. Based on the results of both groups, participants experienced some stress in the treatment sessions.

2. Does Auditory and Visual Simulation Enhance the Participants' Understanding of the Rules?

As stated previously, the FMB is a high fidelity simulator and the audio that is incorporated with this simulator resembles the real world to some degree. The researchers made complex scenarios and utilized every feature that the simulator could offer. The research team was only limited to the depth of view and physical environment characteristics (e.g. wind, smell, sea-spray that the real world provides). Based on the participants' feedback, the researchers were able to conclude that the scenarios were realistic.

3. Were the Scenarios Provided by the Research Team Realistic and Did They Contribute to the Participants' Understanding of the 72 COLREGS and Inland Navigation Rules?

Even though data for this question shows that the participants felt they were able to safely navigate the ship in the sessions, the researchers initially observed inconsistency, delays in decision making, and sometimes wrong actions in respect to following the RoR. By the conclusion of the treatment sessions, the researchers observed only minor delays. The researchers concluded that the initial observations stem from the fact that surface combatants do not normally operate in heavily congested environments such as the scenarios generated for these sessions. Additionally, the participants are junior and their experience in this type of environment is limited, especially if they were not qualified as an OOD while deployed or not a forward deployed surface combatant. In this study, 23 of 27 participants have been deployed overseas; however, only nine of 27 were OOD qualified.

4. Does Auditory and Visual Simulation Enhance the Training Session and Contribute to the Participants' Understanding of the 72 COLREGS and Inland Navigation Rules?

The researchers concluded that incorporating auditory and visual simulation technology into the curriculum may be a key component in learning the RoR. Based on the researcher's observations, students attempted to apply the lessons presented by the RoR instructions in the simulator and throughout each session. More importantly, the researchers observed the participants becoming more confident and knowledgeable with the RoR as the treatment sessions advanced.

5. In Comparison with United States Coast Guard (USCG) Navigation Rules, International—Inland Manual (Commandant Instruction M16672.2D), Was the Full Mission Bridge (FMB) More Effective in Teaching Maneuvering Schemes, Lights, and Sound Signals to the Participants?

The researchers concluded that 88.9 percent of the participants agreed that simulation technology is a more effective tool for learning RoR when compared to the *USCG Navigation Rules for International and Inland Waters* book. The researchers were not surprised by this outcome because the FMB allows its users to be fully immersed in the sessions through its auditory and visual capabilities.

6. Do Participants Feel that Auditory and Visual Simulation Technology Should be Incorporated in Instructing Commandant Instruction M16672.2D?

There is significant evidence that suggests auditory and visual simulation technology should be incorporated in instructing RoR. Considering that both ships and FCAs have several simulators available, simulators are another existing tool that the fleet can use to teach its officers and enlisted personnel the RoR in a practical application.

7. Do Participants Feel More Prepared to Take a 72 COLREGS and Inland Navigation Rules Test After Completing the Research Team's Sessions in Respects to Maneuvering Schemes, Lights, and Sound Signals?

Based on the responses from the participants, the researchers concluded this type of preparation for the RoR test contributed to the mean scores of 93.33 percent for the pilot study group and 91.58 percent for the experimental group.

8. Do Participants Feel That an Interactive Tool Would be Useful in Maintaining 72 COLREGS and Inland Navigation Rules Proficiency in the Fleet?

The researchers concluded that an interactive tool is needed in the fleet to help maintain RoR proficiency based upon the participants' RoR post-study test scores and responses to this question. Surprisingly, 26 of 27 participants have utilized a ship-handling simulator for ship-handling proficiency, but only three of 26 participants experienced an emphasis on the RoR while in that ship-handling simulator.

9. If Provided the Opportunity, Would Participants Use an Interactive Tool to Maintain RoR Proficiency?

Based on the responses from the participants, the researchers concluded that investing in an interactive tool or utilizing existing technologies in the fleet would be beneficial to maintain RoR proficiency.

D. STUDY LIMITATIONS AND LESSONS LEARNED

This study did not encounter any major limitations that prevented the research team from gathering the necessary data needed to conduct this research. By having qualified SWOS instructors conducting the study and operating the FMB simulator, any major limitations were mitigated during the research design and development of scenarios. Additionally, with the assistance of SWOS Newport technicians, any simulator faults were resolved prior to the treatment groups arriving for their sessions.

The study could have been improved if detailed information of the study was provided to SWOS Newport instructors several months prior to conducting the study, by incorporating DH students into the study, and by having a more in-depth understanding of the simulator software. With these improvements, there could have been a larger sample population and scenarios may have been more complex.

E. FUTURE WORK

This thesis was only conducted with ASAT students enrolled at SWOS Newport and should be extended to DH students at that command if a similar study is to be conducted at SWOS Newport. Additionally, the fleet can use its existing RoR Perception test database results (control group) and conduct a similar study within each of the FCAs and onboard ships. The research data collected in this future work may only validate the need to incorporate simulation technology into traditional classroom settings, such as RoR training.

If this new training design shows statistically significant improvements in RoR knowledge through practical application, then investing in desktop simulation should be explored for the retention of RoR knowledge for shipboard or ashore personnel. This may be ideal because it could introduce gaming engine technology into a desktop simulation tool to teach RoR lectures to bridge watchstanders and other operators of naval vessels (i.e. RHIBs). Ultimately, this could increase the availability of full scale simulators such as POLARIS II at FCAs and assist in maintaining the required RoR proficiency in the fleet as stated in COMNAVSURFPAC & COMNAVSURFLANT Instructions 3505.1 and 3502.3.

F. RECOMMENDATIONS

From this study, the research team recommends that the fleet and institutions that have ship-handling simulators incorporate their simulators into RoR training or curricula and not solely in ship-handling. Scenarios should be designed that place the users in situations they will likely encounter during actual ship-handling in which they will need to successfully apply RoR during a high

stress situation, such as a straits or harbor transit. This training can be based on individual or bridge team training, specific location training (i.e., strait transit), while incorporating various environmentals. The research team believes that this type of training will only help improve the proficiency and situational awareness for bridge watchstanders. While this study only focused on warships, this type of training can be extended to coxswains who operate RHIBs.

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APPENDIX A. PILOT STUDY GROUP: DEMOGRAPHIC SURVEY AND SUMMARY STATISTICS

A. DEMOGRAPHIC SURVEY SAMPLE

DEMOGRAPHIC SURVEY

Participant ID (Last 4 digits of telephone number): _____

Please **CIRCLE YOUR ANSWERS**. If you are unsure of the question, ask researcher for further guidance.

1. What was your commissioning source?

   Naval Academy / Maritime Academy / NROTC / OCS

2. How many months have you been onboard your ship?

   Less than 12 months / 12 months – 18 months / Greater than 18 months

3. Do you take the Rules of the Road exam monthly?

   Yes / No a. If no, how often do you take it? _____

4. Are you Officer of the Deck qualified?

   Yes / No a. If yes, how many months have you been OOD qualified? _____

5. Have you been deployed overseas?

   Yes / No a. If yes, how many months did you serve on the deployment? _____

   b. If yes, did you stand OOD during that deployment? _____

6. Have you used a simulator for shiphandling training?

   Yes / No a. If yes, how many times? _____

   b. If yes, was emphasis placed on RoR? Yes / No

7. On a scale of "7" (Strong Agreement) to "1" (strong disagreement), simulation technology is an effective learning tool.

Strongly Agree						Strongly Disagree
7	6	5	4	3	2	1

Figure 37. Demographic Survey Sample

B. SUMMARY ANALYSIS OF DEMOGRAPHIC SURVEY

1. What Was Your Commissioning Source?

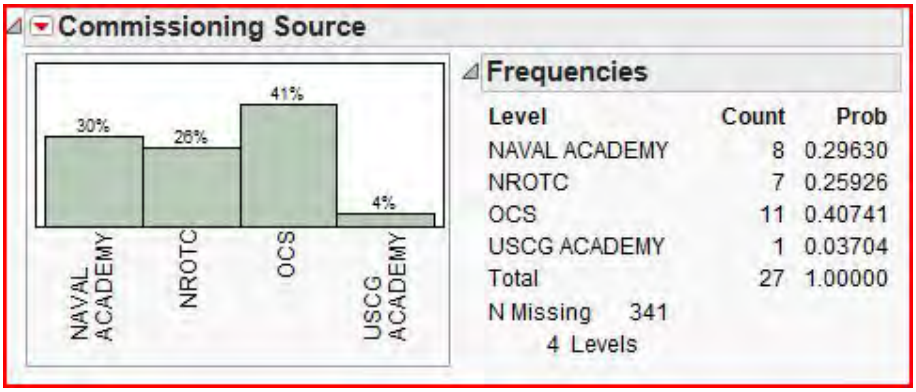

Figure 38. Participants Commissioning Source

2. How Many Months Have You Been Onboard Your Ship?

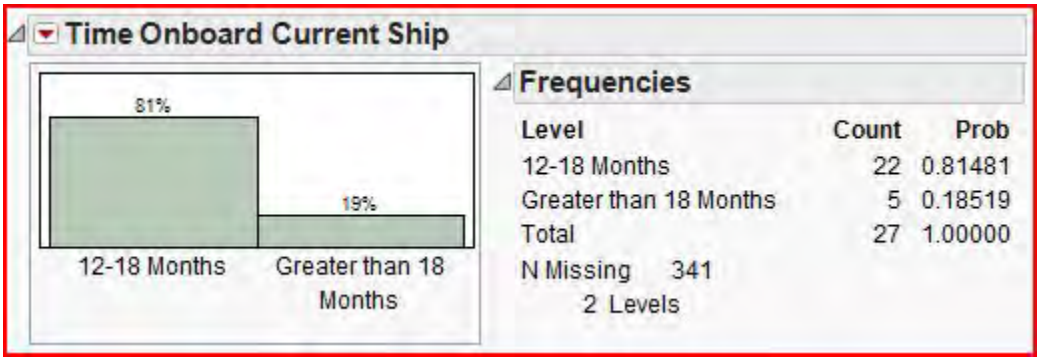

Figure 39. Number of Months Participants Have Been Onboard Current Ship

3. Do You Take the Rules of the Road Exam Monthly?

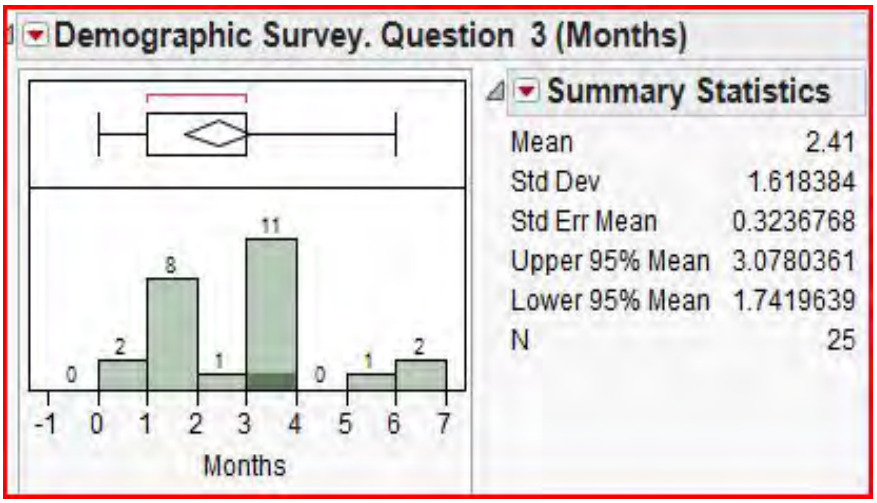

Figure 40. Frequency in Which the Rules of the Road Test is Administered Onboard Participants Ship

4. Are You Officer of the Deck Qualified?

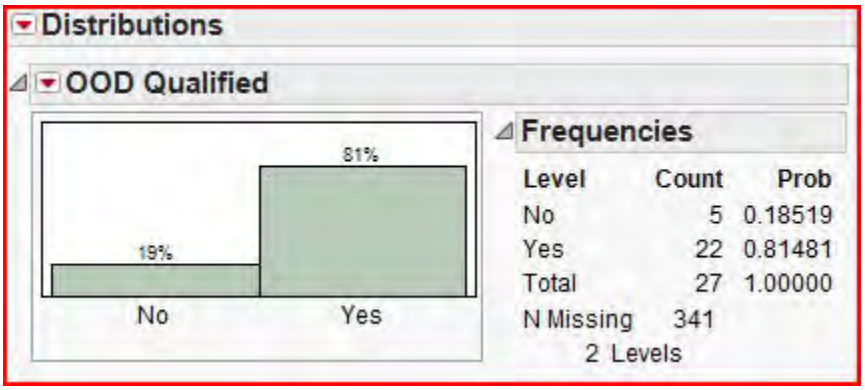

Figure 41. Percentage of Participants Who Are Officer of the Deck Qualified

4a. If Yes, How Many Months Have You Been OOD Qualified?

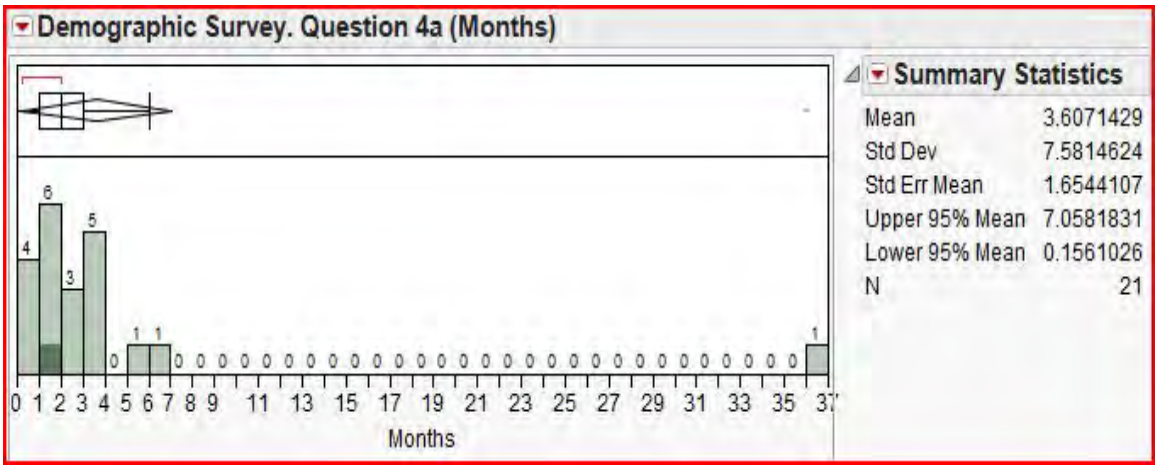

Figure 42. Number of Months That the Officer of Decks Have Been Qualified

5. Have You Been Deployed Overseas?

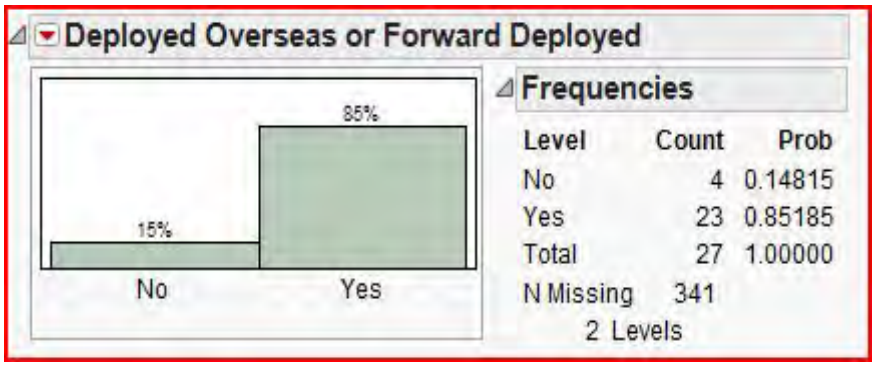

Figure 43. Percentage of Participants Who Have Been Deployed Overseas or Are Forward Deployed

5a. If yes, how many months did you serve on the deployment?

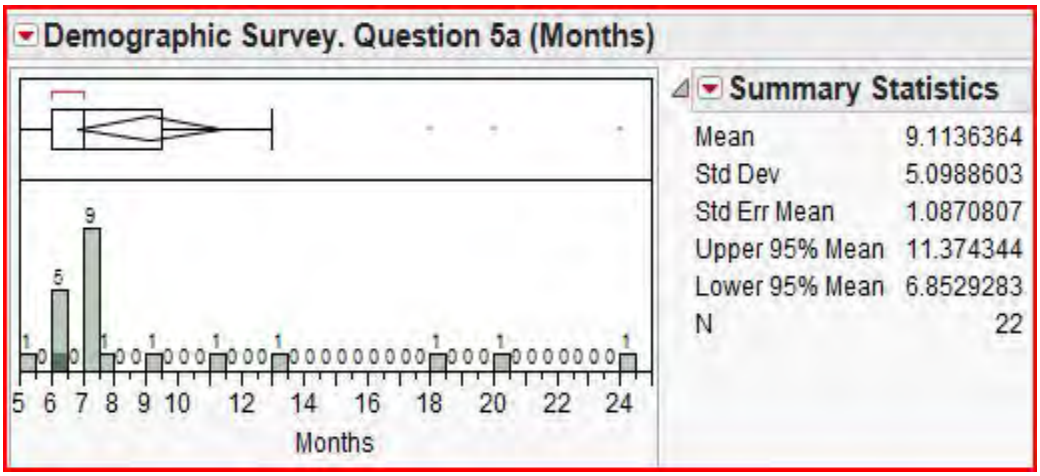

Figure 44. Number of Months Participants Have Been Deployed

5b. If yes, did you stand OOD during that deployment?

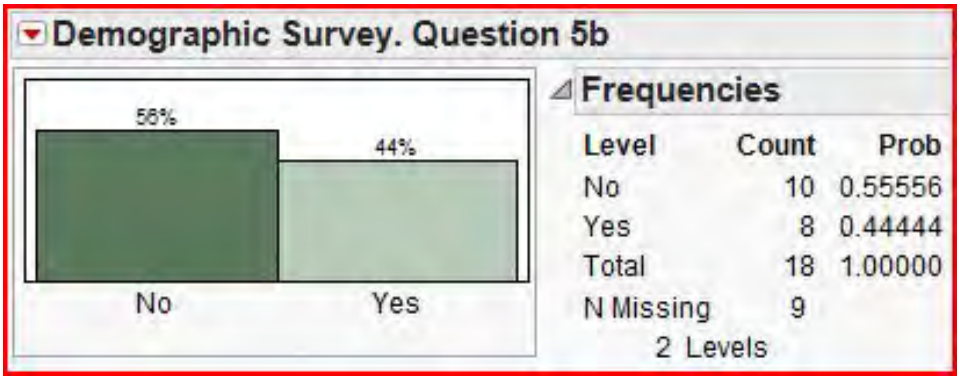

Figure 45. Percentage of Qualified Officer of the Decks Who Stood Officer of the Deck While Deployed

6. Have you used a simulator for ship-handling training?

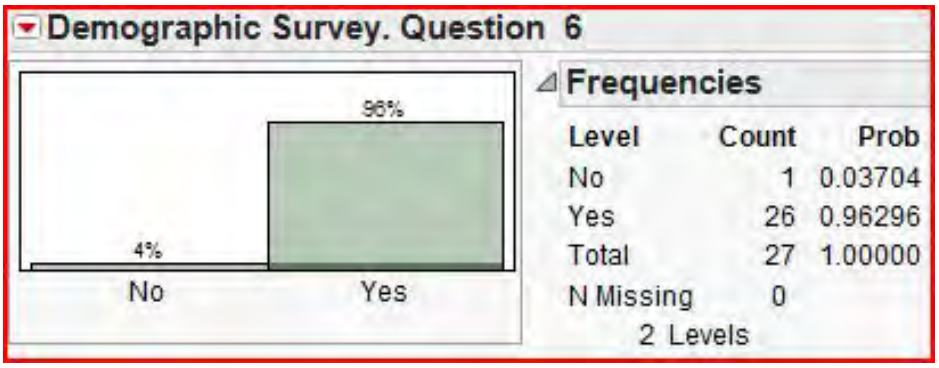

Figure 46. Percentage of Participants Who Have Used a Simulator for Shiphandling

6a. If yes, how many times?

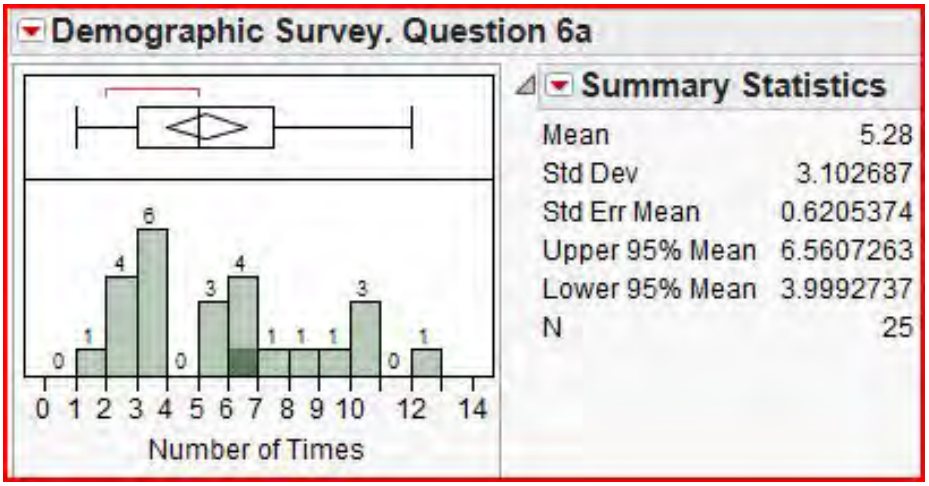

Figure 47. Number of Times Participants Have Used a Shiphandling Simulator

6b. If yes, was emphasis placed on RoR?

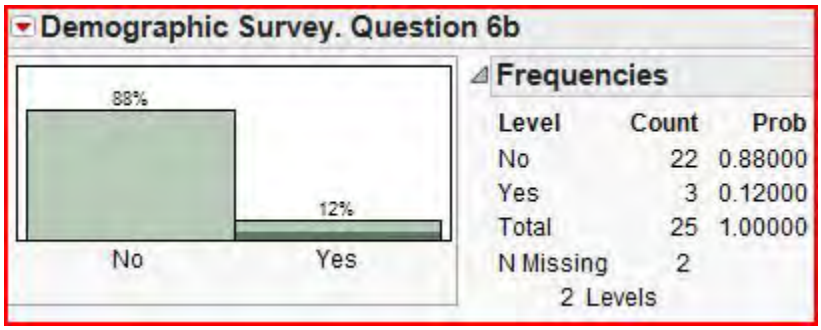

Figure 48. Percentage of Participants Whose Shiphandling Simulator Experience Placed an Emphasis on Rules of the Road

7. On a scale of "7" (Strong Agreement) to "1" (Strong Disagreement), simulation technology is an effective learning tool.

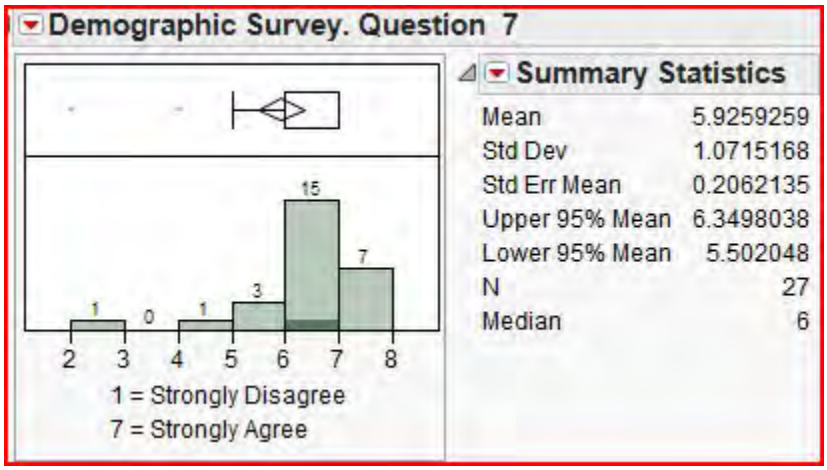

Figure 49. Effectiveness of Simulation Technology as an Effective Learning Tool

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APPENDIX B. PILOT STUDY: PRACTICE ROR POST-TEST

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

This Post-Test covering RoR is for RESEARCH PURPOSES ONLY and is not to be used for normal curriculum.

1. BOTH INTERNATIONAL & INLAND At night, a power-driven vessel less than 12 meters in length may, instead of the normal navigation lights, show sidelights and one _____.

- • (a) white light
- o (b) yellow light
- o (c) flashing white light
- o (d) flashing yellow light

2. BOTH INTERNATIONAL & INLAND Power-driven vessels must keep out of the way of sailing vessels except _____.

- o (a) in a crossing situation
- o (b) when they are making more speed than the power-driven vessel
- • (c) when the sailing vessel is overtaking
- o (d) on the Inland Waters of the United States

3. BOTH INTERNATIONAL & INLAND Which statement is TRUE when you are towing more than one barge astern at night?

- o (a) Only the last barge in the tow must be lighted.
- o (b) Only the first and last barges in the tow must be lighted.
- • (c) All barges in the tow must be lighted.
- o (d) All barges, except unmanned barges, must be lighted.

4. INLAND ONLY Passing signals shall be sounded on inland waters by _____.

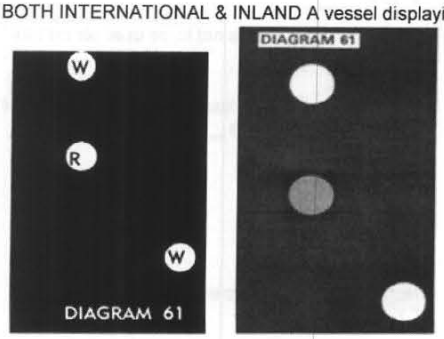
- o (a) all vessels upon sighting another vessel rounding a bend in the channel
- o (b) a towing vessel when meeting another towing vessel on a clear day with a 0.6 mile CPA (Closest Point of Approach)
- • (c) a power-driven vessel when crossing less than half a mile ahead of another power-driven vessel
- o (d) All of the above

5. BOTH INTERNATIONAL & INLAND Which statement is TRUE concerning a vessel equipped with operational radar?

- • (a) She must use this equipment to obtain early warning of risk of collision.
- o (b) The use of a radar excuses a vessel from the need of a look-out.
- o (c) The radar equipment is only required to be used in restricted visibility.
- o (d) The safe speed of such a vessel will likely be greater than that of vessels without radar.

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

6. BOTH INTERNATIONAL & INLAND A vessel displaying ONLY the lights shown is _____.



- ○ (a) fishing
- • (b) a pilot vessel at anchor
- ○ (c) a fishing vessel aground
- ○ (d) fishing and hauling her nets

7. BOTH INTERNATIONAL & INLAND What is a requirement for any action taken to avoid collision?

- ○ (a) When in sight of another vessel, any action taken must be accompanied by sound signals.
- ○ (b) The action taken must include changing the speed of the vessel.
- • (c) The action must be positive and made in ample time.
- ○ (d) All of the above

8. BOTH INTERNATIONAL & INLAND A vessel proceeding along a narrow channel shall _____.

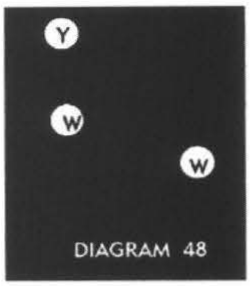
- ○ (a) avoid crossing the channel at right angles
- ○ (b) not overtake any vessels within the channel
- • (c) keep as near as safe and practicable to the limit of the channel on her starboard side
- ○ (d) when nearing a bend in the channel, sound a long blast of the whistle

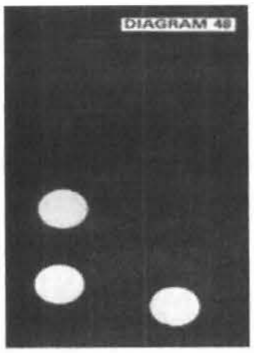
9. BOTH INTERNATIONAL & INLAND When is a stand-on vessel FIRST allowed by the Rules to take action in order to avoid collision?

- ○ (a) When the two vessels are less than half a mile from each other.
- • (b) When the give-way vessel is not taking appropriate action to avoid collision.
- ○ (c) When collision is imminent.
- ○ (d) The stand-on vessel is never allowed to take action.

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

10. BOTH INTERNATIONAL & INLAND The display of lights shown could represent a _____.





- • (a) tug and a barge being towed astern
- ○ (b) sailing vessel
- ○ (c) a vessel not under command
- ○ (d) a submarine on the surface

11. BOTH INTERNATIONAL & INLAND A vessel engaged in fishing, and at anchor, should exhibit _____.

- ○ (a) an anchor light
- ○ (b) sidelights and stern light
- ○ (c) three lights in a vertical line, the highest and lowest being red, and the middle being white
- • (d) None of the above

12. BOTH INTERNATIONAL & INLAND Every vessel that is to keep out of the way of another vessel must take positive early action to comply with this obligation and must _____.

- • (a) avoid crossing ahead of the other vessel
- ○ (b) avoid passing astern of the other vessel
- ○ (c) sound one prolonged blast to indicate compliance
- ○ (d) alter course to port for a vessel on her port side

13. INLAND ONLY Which statement is TRUE concerning the Inland Navigation Rules?

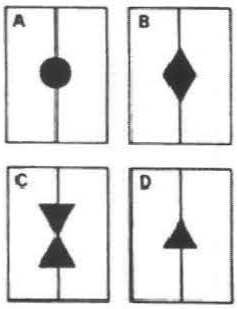
- • (a) They list requirements for Traffic Separation Schemes.
- ○ (b) They define moderate speed.
- ○ (c) They require communication by radiotelephone to reach a passing agreement.
- ○ (d) All of the above

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

14. BOTH INTERNATIONAL & INLAND A vessel using a traffic separation scheme is forbidden to _____.

- • (a) proceed through an inappropriate traffic lane
- ○ (b) engaged in fishing in the separation zone
- ○ (c) cross a traffic lane
- ○ (d) enter the separation zone, even in a emergency

15. BOTH INTERNATIONAL & INLAND Which of the day-shapes shown indicates a vessel with a tow exceeding 200 meters in length?



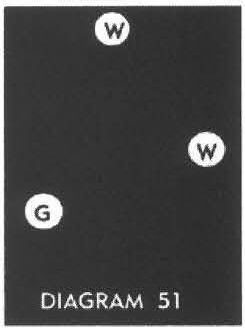
- ○ (a) A
- • (b) B
- ○ (c) C
- ○ (d) D

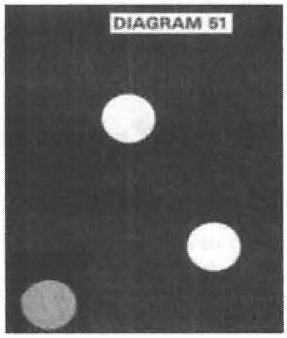
16. BOTH INTERNATIONAL & INLAND Two vessels are approaching each other near head on. What action should be taken to avoid collision?

- ○ (a) The first vessel to sight the other should give way.
- ○ (b) The vessel making the slower speed should give way.
- • (c) Both vessels should alter course to starboard.
- ○ (d) Both vessels should alter course to port.

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

17. BOTH INTERNATIONAL & INLAND You are on a vessel heading due north and see the lights shown one point on your port bow. This vessel could be heading _____.





- ○ (a) NW
- • (b) SE
- ○ (c) SW
- ○ (d) NE

18. BOTH INTERNATIONAL & INLAND Your tug is underway at night and NOT towing. What light(s) should your vessel show aft to other vessels coming up from astern?

- • (a) One white light
- ○ (b) Two white lights
- ○ (c) One white light and one yellow light
- ○ (d) One white light and two yellow lights

19. BOTH INTERNATIONAL & INLAND Which statement is true concerning a towing light when a towing vessel is towing astern?

- ○ (a) When a towing light is shown, no stern light is necessary.
- ○ (b) When a stern light is shown, no towing light is necessary.
- ○ (c) The towing light is shown below the stern light.
- • (d) The towing light is shown above the stern light.

20. BOTH INTERNATIONAL & INLAND A seagoing tug has a tow greater than 200 meters as shown and is severely restricted in her ability to deviate from her course. Which lights would be displayed from the towing vessel?

- • (a) Three white masthead lights, red-white-red all-round lights, sidelights, stern light and a towing light
- ○ (b) Three white masthead lights, red-white-red all-round lights, sidelights and two towing lights
- ○ (c) Three white masthead lights, two all-round red lights, sidelights, stern light and a towing light
- ○ (d) None of the above

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

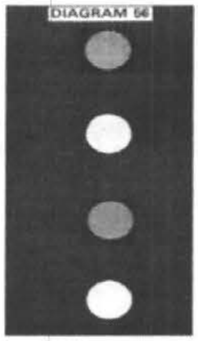
21. BOTH INTERNATIONAL & INLAND At night a vessel displaying the lights as shown is _____.

- ○ (a) a pilot boat
- ○ (b) sailing
- ○ (c) anchored
- • (d) fishing

22. BOTH INTERNATIONAL & INLAND A vessel will NOT show sidelights when _____.

- ○ (a) underway but not making way
- ○ (b) making way, not under command
- • (c) not under command, not making way
- ○ (d) trolling underway

23. BOTH INTERNATIONAL & INLAND A vessel displaying the lights shown could be a vessel _____.



- ○ (a) fishing at anchor
- • (b) dredging while underway
- ○ (c) transferring dangerous cargo at a berth
- ○ (d) restricted in her ability to maneuver, underway but not making way

24. INTERNATIONAL ONLY If you sighted three red lights in a vertical line on another vessel at night, it would be a vessel _____.

- ○ (a) aground
- • (b) constrained by her draft
- ○ (c) dredging
- ○ (d) moored over a wreck

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

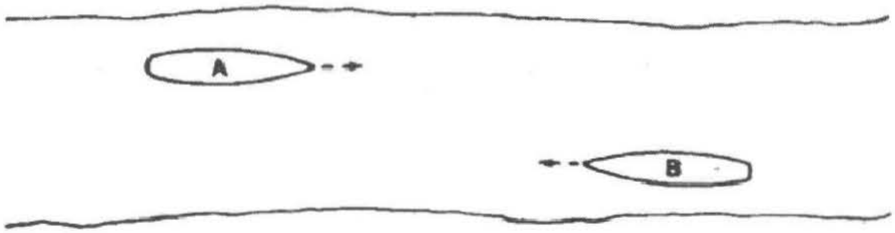
25. INTERNATIONAL ONLY When two vessels are in sight of one another, all of the following signals may be given EXCEPT _____.

- ○ (a) a light signal of at least five short and rapid flashes
- • (b) four short whistle blasts
- ○ (c) one prolonged, one short, one prolonged and one short whistle blasts
- ○ (d) two short whistle blasts

26. BOTH INTERNATIONAL & INLAND While underway your vessel approaches a bend in a river where, due to the bank, you cannot see around the bend. You should _____.

- ○ (a) keep to the starboard side of the channel and sound one short blast
- ○ (b) sound the danger signal
- • (c) sound one prolonged blast
- ○ (d) slow your vessel to bare steerageway

27. BOTH INTERNATIONAL & INLAND Vessels "A" and "B" are meeting in a narrow channel as shown but are not in sight of one another due to restricted visibility. Which statement is TRUE concerning whistle signals between the vessels?



- ○ (a) Both vessels should sound two short blasts.
- ○ (b) Both vessels should sound one short blast.
- ○ (c) Vessel "A" should sound one short blast and vessel "B" should sound two short blasts.
- • (d) None of the above statements is TRUE.

28. BOTH INTERNATIONAL & INLAND While underway in fog, you hear a vessel ahead sound two short blasts on the whistle. You should _____.

- ○ (a) not sound any whistle signals until the other vessel is sighted
- • (b) sound only fog signals until the other vessel is sighted
- ○ (c) sound whistle signals only if you change course
- ○ (d) sound two short blasts and change course to the left

PARTICIPANT ID (LAST FOUR NUMBERS OF TELEPHONE NUMBER): _____

29. BOTH INTERNATIONAL & INLAND A power-driven vessel making way through the water sounds a fog signal of _____.

- • (a) one prolonged blast at intervals of not more than two minutes
- ○ (b) two prolonged blasts at intervals of not more than two minutes
- ○ (c) one prolonged blast at intervals of not more than one minute
- ○ (d) two prolonged blasts at intervals of not more than one minute

30. BOTH INTERNATIONAL & INLAND A vessel aground in fog shall sound, in addition to the proper anchor signal, which of the following?

- ○ (a) Three strokes on the gong before and after sounding the anchor signal
- • (b) Three strokes on the bell before and after the anchor signal
- ○ (c) Four short blasts on the whistle
- ○ (d) One prolonged and one short blast on the whistle

APPENDIX C. EXPERIMENTAL AND CONTROL GROUP: PRACTICE ROR POST-TEST

RoR Study Post-Test

This Student RoR Practice Test covering RoR is for RESEARCH PURPOSES ONLY and grading is not to be used for normal curriculum.

1. BOTH INTERNATIONAL & INLAND A towing light _____.

(a) Flashes at regular intervals of 50-70 flashes per second
(b) is yellow in color
(c) shows an unbroken light over an arc of the horizon
(d) all of the above

2. BOTH INTERNATIONAL & INLAND At night, you see three lights; white over red over white in a vertical column. This would indicate a vessel _____.

(a) restricted in her ability to maneuver
(b) engaged in fishing and making way
(c) on pilotage duty and underway
(d) not under command

3. BOTH INTERNATIONAL & INLAND The display of 2 vertical lights; yellow over white could represent a _____.

(a) tug and a barge being towed astern
(b) sailing vessel
(c) a vessel not under command
(d) a submarine on the surface

4. BOTH INTERNATIONAL & INLAND A power-driven vessel, when towing another vessel astern shall show the following lights

(a) Two yellow lights, one over the other
(b) A yellow light over a white light
(c) A single yellow light
(d) None of the above

5. BOTH INTERNATIONAL & INLAND A vessel displaying the day-shape of a diamond.

(a) is at anchor
(b) is not under command
(c) has a tow that exceeds 200 meters in length
(d) has a tow that is carrying dangerous cargo

6. BOTH INTERNATIONAL & INLAND A vessel engaged in fishing, and at anchor, should exhibit _____.

(a) an anchor light
(b) sidelights and stern light
(c) three lights in a vertical line, the highest and lowest being red, and the middle being white
(d) None of the above

7. BOTH INTERNATIONAL & INLAND A vessel is "in sight" of another vessel when _____.

(a) she can be observed by radar
(b) she can be observed visually from the other vessel
(c) she can be plotted on radar well enough to determine her heading
(d) her fog signal can be heard

Page 1

8. BOTH INTERNATIONAL AND INLAND A vessel may enter a traffic separation zone _____.

(a) in an emergency
(b) to engage in fishing within the zone
(c) to cross the traffic separation zone
(d) all of the above

9. BOTH INTERNATIONAL & INLAND A vessel proceeding along a narrow channel shall _____.

(a) avoid crossing the channel at right angles
(b) not overtake any vessels within the channel
(c) keep as near as safe and practicable to the limit of the channel on her starboard side
(d) when nearing a bend in the channel, sound a long blast of the whistle

10. BOTH INTERNATIONAL AND INLAND A vessel will NOT show sidelights when _____.

(a) underway but not making way
(b) making way, not under command
(c) not under command, not making way
(d) trolling underway

11. BOTH INTERNATIONAL AND INLAND All of the following are distress signals under the Rules EXCEPT _____.

(a) International Code Signal AA
(b) orange-colored smoke
(c) red flares
(d) the repeated raising and lowering of outstretched arms

12. BOTH INTERNATIONAL AND INLAND At night, which lights would you see on a vessel engaged in fishing, other than trawling?

(a) Two red lights, one over the other
(b) A green light over a red light
(c) A red light over a white light
(d) A white light over a red light

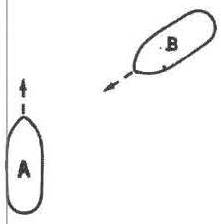
13. BOTH INTERNATIONAL & INLAND In fog you observe your radar and determine that risk of collision exists with a vessel which is 2 miles off your port bow. You should _____.

(a) stop your engines
(b) sound the danger signal at two-minute intervals
(c) hold course and speed until the other vessel is sighted
(d) take avoiding action as soon as possible

14. BOTH INTERNATIONAL & INLAND Risk of collision may be deemed to exist _____.

(a) if the compass bearing of an approaching vessel does not change a appreciably.
(b) even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range
(c) if you observe both sidelights of a vessel ahead and a masthead light when applicable.
(d) All of the above

15. BOTH INTERNATIONAL & INLAND Vessels "A" and "B" are crossing as shown. Which statement is TRUE?



(a) The vessels should pass starboard to starboard.
(b) Vessel "B" should pass astern of vessel "A".
(c) Vessel "B" should alter course to the right.
(d) Vessel "A" must keep clear of vessel "B".

16. BOTH INTERNATIONAL & INLAND Which signal, other than a distress signal, can be used by a vessel to attract attention?

(a) Searchlight beam
(b) Continuous sounding of a fog signal apparatus
(c) Burning barrel
(d) Orange smoke signal

17. BOTH INTERNATIONAL & INLAND Which statement is TRUE concerning a vessel equipped with operational radar?

(a) She must use this equipment to obtain early warning of risk of collision.
(b) The use of radar excuses a vessel from the need of a look-out.
(c) The radar equipment is only required to be used in restricted visibility.
(d) The safe speed of such a vessel will likely be greater than that of vessels without radar.

18. BOTH INTERNATIONAL & INLAND Which vessel is NOT to be regarded as "restricted in her ability to maneuver"?

(a) A vessel transferring provisions while underway
(b) A pushing vessel and a vessel being pushed when connected in a composite unit
(c) A vessel servicing a navigation mark
(d) A vessel launching aircraft

19. BOTH INTERNATIONAL & INLAND Which vessel is NOT to impede the passage of a vessel which can only navigate safely within a narrow channel?

(a) Any vessel less than 20 meters in length
(b) Any sailing vessel
(c) A vessel engaged in fishing
(d) All of the above

20. BOTH INTERNATIONAL & INLAND Which vessel may combine her sidelights and stern light in one lantern on the fore and aft centerline of the vessel?

(a) A 16-meter sailing vessel
(b) A 25-meter power-driven vessel
(c) A 28-meter sailing vessel
(d) Any non-self-propelled vessel

21. BOTH INTERNATIONAL & INLAND Which vessel must exhibit forward and after masthead lights when underway?

(a) A 200-meter sailing vessel
(b) A 50-meter power-driven vessel
(c) A 100-meter vessel engaged in fishing
(d) All of the above

22. BOTH INTERNATIONAL & INLAND Which vessel would display a cone, apex downward?

(a) A fishing vessel with outlying gear
(b) A vessel proceeding under sail and machinery
(c) A vessel engaged in diving operations
(d) A vessel being towed

23. BOTH INTERNATION & INLAND While underway in fog you hear a rapid ringing of a bell ahead. This bell indicates a _____.

(a) vessel at anchor
(b) vessel in distress
(c) sailboat underway
(d) vessel backing out of a berth

24. BOTH INTERNATIONAL & INLAND Working lights shall be used to illuminate the decks of a vessel _____.

(a) over 100 meters at anchor
(b) not under command
(c) constrained by her draft
(d) All of the above

25. BOTH INTERNATIONAL & INLAND You are the stand-on vessel in a crossing situation. You may hold your course and speed until _____.

(a) the other vessel takes necessary action
(b) the other vessel gets to within half a mile of your vessel
(c) action by the give-way vessel alone will not prevent collision
(d) the other vessel gets to within a quarter mile of your vessel

26. BOTH INTERNATIONAL & INLAND You see a vessel displaying the day signal: ball, diamond, ball. The vessel may be _____.

(a) not under command
(b) fishing with trawls
(c) laying cable
(d) aground

27. INLAND ONLY What is true of a special flashing light?

(a) It may show through an arc of not than 180 degrees.
(b) It flashes at the rate of 120 flashes per minute.
(c) It is optional below the Baton Rouge Highway Bridge
(d) All of the above

28. INTERNATIONAL ONLY A signal of one prolonged, one short, one prolonged, and one short blast, in that order is given by a vessel _____.

(a) engaged on pilotage duty
(b) in distress
(c) at anchor
(d) being overtaken in a narrow channel

29. INTERNATIONAL ONLY A vessel displaying three red lights in a vertical line is _____.

(a) restricted in her ability to maneuver
(b) not under command
(c) engaged in mineclearance operations
(d) constrained by her draft

30. INTERNATIONAL ONLY Your vessel is crossing a narrow channel. A vessel to port is within the channel and crossing your course. She is showing a black cylinder. You should _____.

(a) hold your course and speed
(b) not impede the other vessel
(c) exchange passing signals
(d) sound the danger signal

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APPENDIX D. CONTROL GROUP: ROR PRACTICE TEST ANALYSIS

Test Analysis Report

Assessment name	Student ROR Practice	Assessment description	
Assessment author	David Zierdt	Assessment ID	4217305833578
Assessment last modified	Apr 17 2012 00:00:00	Report date & time	Jun 12 2012 09:54:11

Filters

All dates

Group name equals ASAT 281, ASAT 282, ASAT 283, ASAT 284, ASAT 285, ASAT 286, ASAT 287, ASAT 288, ASAT 290

Participants who finished

MaxPossibleScoreText:

Table of Test Statistics

Number of examinees	341	Mean	21.27/30 (70.9%)	Standard error of mean	0.16/30 (0.5%)
Number of items	30	Median	21/30 (70%)	Standard error of measurement	1.79/30 (5.97%)
Maximum possible score	30	Mode	21/30 (70%)	Skew	-1.882
Minimum achieved score	0/30 (0%)	Standard deviation	2.8/30 (9.33%)	Kurtosis	11.811
Maximum achieved score	29/30 (96.67%)	Variance	7.82/30 (26.07%)	Test reliability (Cronbach's Alpha)	0.592

Reliability is most meaningful if all items cover the same subject area.

Reliability (Topic Level)

Topic	Number of items	Mean	Standard deviation	Reliability
ROR\Rule 10	1	0.91/1 (91%)	0.28/1 (28%)	-
ROR\Rule 15	1	0.92/1 (92%)	0.28/1 (28%)	-
ROR\Rule 17	1	0.99/1 (99%)	0.12/1 (12%)	-
ROR\Rule 21	2	1.07/2 (53.5%)	0.62/2 (31%)	0.348
ROR\Rule 23	1	0.45/1 (45%)	0.5/1 (50%)	-
ROR\Rule 24	3	1.86/3 (62%)	0.43/3 (14.33%)	-1.052
ROR\Rule 25	2	1.79/2 (89.5%)	0.46/2 (23%)	0.215
ROR\Rule 26	2	1.51/2 (75.5%)	0.62/2 (26%)	0.052
ROR\Rule 27	2	1.57/2 (78.5%)	0.57/2 (28.5%)	0.152
ROR\Rule 28	1	0.68/1 (68%)	0.32/1 (32%)	-
ROR\Rule 29	1	0.45/1 (45%)	0.5/1 (50%)	-
ROR\Rule 3	2	1.93/2 (96.5%)	0.28/2 (14%)	0.359
ROR\Rule 30	1	0.94/1 (94%)	0.23/1 (23%)	-
ROR\Rule 34	1	0.84/1 (84%)	0.37/1 (37%)	-

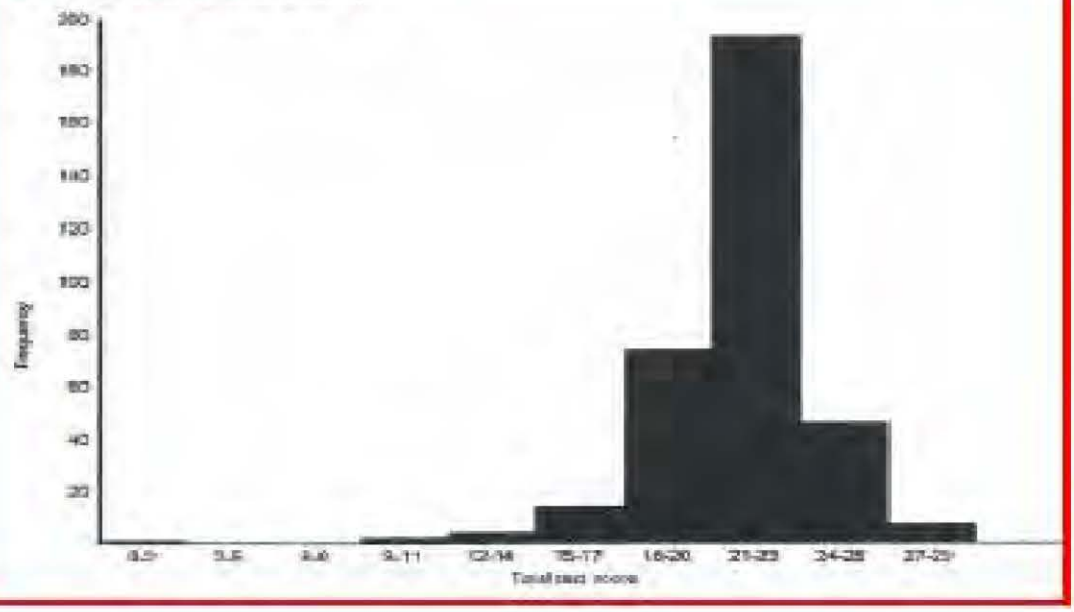
1/3

RORRule 35	1	0.79/1 (79%)	0.43/1 (43%)	-
RORRule 36	1	0.69/1 (69%)	0.46/1 (46%)	-
RORRule 37	1	1/1 (100%)	0/1 (0%)	-
RORRule 7	2	1.9/2 (95%)	0.3/2 (15%)	0.101
RORRule 8	1	0.85/1 (85%)	0.36/1 (36%)	-
RORRule 9	3	2.76/3 (92%)	0.48/3 (16%)	0.132

Frequency distribution of total test scores

Raw Score	Number	Percentage	Cumulative percentage
0	1	0.29	0.29
9	2	0.59	0.88
13	3	0.88	1.76
14	1	0.29	2.05
15	3	0.88	2.93
16	3	0.88	3.81
17	8	2.35	6.16
18	17	4.99	11.14
19	18	5.28	16.42
20	39	11.44	27.86
21	80	23.46	51.32
22	69	20.23	71.55
23	44	12.9	84.46
24	34	9.97	94.43
25	10	2.93	97.36
26	2	0.59	97.96
27	2	0.59	98.53
28	1	0.29	98.83
29	4	1.17	100

Histogram of total test scores



APPENDIX E. POST-STUDY QUESTIONNAIRE

Treatment Group Post-Study Questionnaire

Participant ID: _____

1. In your opinion, on a scale of stress ranging from 0 to 10, with "10" being the highest stress and "0" being no stress, what was your highest level of stress during the study?

   Stress level _____ .

For each of the following statements indicate the extent to which to AGREE with that statement. A "7" indicates strong agreement with the statement and a "1" indicates strong disagreement with the statement.

	Strongly Agree						Strongly Disagree
1. I feel that the sessions were realistic and contributed to my RoR knowledge.	7	6	5	4	3	2	1
2. I felt that I was able to safely navigate the ship in each session.	7	6	5	4	3	2	1
3. Utilizing the radar helped me with my navigation.	7	6	5	4	3	2	1
4. Utilizing VMS helped me with my navigation.	7	6	5	4	3	2	1
5. Auditory and visual simulation enhanced the training session and contributed to my learning.	7	6	5	4	3	2	1
6. In comparison with USCG Navigation Rules book, FBM was more effective in learning maneuvering schemes, lights, and sound signals.	7	6	5	4	3	2	1
7. I feel that auditory and visual simulation technology should be incorporated in instructing USCG Navigation Rules.	7	6	5	4	3	2	1
8. I feel more prepared to take a RoR exam after completing these sessions in respects to maneuvering schemes, lights, and sound signals.	7	6	5	4	3	2	1
9. I feel that an interactive tool would be useful in maintaining RoR proficiency in the Fleet.	7	6	5	4	3	2	1
10. If provided the opportunity, I would use an interactive tool to maintain RoR proficiency.	7	6	5	4	3	2	1

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APPENDIX F. PILOT STUDY: TREATMENT SESSION ONE ENTITIES

Objects (refreshed every 3 s.)

Label	Model	Position
1000m Fog Bank	1000m Fog Bank	40 20.43N, 73 30.66W
1000m Fog Bank 2	1000m Fog Bank	40 20.17N, 73 31.14W
1000m Fog Bank 3	1000m Fog Bank	40 20.39N, 73 29.96W
1000m Fog Bank 4	1000m Fog Bank	40 19.41N, 73 29.48W
1000m Fog Bank 5	1000m Fog Bank	40 20.68N, 73 30.15W
1000m Fog Bank 6	1000m Fog Bank	40 19.65N, 73 31.08W
1000m Fog Bank 7	1000m Fog Bank	40 19.55N, 73 30.54W
1000m Fog Bank 8	1000m Fog Bank	40 19.68N, 73 29.93W
1000m Fog Bank 9	1000m Fog Bank	40 20.14N, 73 29.71W
Cargo Inland Blue	Cargo Inland Blue	40 29.13N, 73 27.60W
CG47	CG47	40 19.88N, 73 30.42W
Containership APL C10 NUC	Containership APL C10 Black	40 20.16N, 73 31.24W
Containership Knud Maersk RMD	Containership Knud Maersk	40 20.32N, 73 31.49W
Cruise Ship Grand Princess	Cruise Ship Grand Princess	40 24.30N, 73 32.38W
Cruise Ship Grand Princess 2	Cruise Ship Grand Princess	40 15.73N, 73 25.79W
Ferry Turbo Cat Anchor Run	Ferry TurboCat	40 20.66N, 73 31.92W
Fishing Boat Trawling	Fishing Boat Trawling	40 21.76N, 73 30.59W
Fishing Boat Trawling 10	Fishing Boat Trawling	40 21.13N, 73 40.64W
Fishing Boat Trawling 11	Fishing Boat Trawling	40 24.56N, 73 41.71W
Fishing Boat Trawling 12	Fishing Boat Trawling	40 24.28N, 73 41.26W
Fishing Boat Trawling 13	Fishing Boat Trawling	40 24.63N, 73 40.84W
Fishing Boat Trawling 14	Fishing Boat Trawling	40 23.90N, 73 41.06W
Fishing Boat Trawling 15	Fishing Boat Trawling	40 23.87N, 73 40.50W
Fishing Boat Trawling 19	Fishing Boat Trawling	40 21.67N, 73 30.89W
Fishing Boat Trawling 20	Fishing Boat Trawling	40 21.75N, 73 30.82W
Fishing Boat Trawling 21	Fishing Boat Trawling	40 21.61N, 73 30.76W
Fishing Boat Trawling 22	Fishing Boat Trawling	40 21.61N, 73 30.58W
Fishing Boat Trawling 3	Fishing Boat Trawling	40 21.68N, 73 30.70W
Fishing Boat Trawling 6	Fishing Boat Trawling	40 20.22N, 73 31.49W
Fishing Boat Trawling 7	Fishing Boat Trawling	40 20.26N, 73 31.55W
Fishing Boat Trawling 8	Fishing Boat Trawling	40 20.96N, 73 40.98W
Fishing Boat Trawling 9	Fishing Boat Trawling	40 21.27N, 73 41.24W
Helicopter SeaHawk God Eye View	Helicopter SeaHawk	40 19.89N, 73 30.48W
Pilot Vessel	Pilot Vessel	40 20.18N, 73 31.43W
PowerBoat Cabin Cruiser	PowerBoat Cabin Cruiser	40 20.78N, 73 32.05W
RoRo 1	RoRo LMSR	40 23.57N, 73 38.15W
Sailboat Yacht	Sailboat Yacht	40 20.69N, 73 31.15W
Sailboat Yacht 4	Sailboat Yacht	40 23.44N, 73 38.90W
Tanker 132k 2	Tanker 132k	40 20.50N, 73 31.74W
Tanker 132k 3	Tanker 132k	40 18.64N, 73 31.12W
Tanker 80k	Tanker 80k	40 29.39N, 73 28.60W
Tug Barge Pushing Sand	Tug Barge Pushing Sand	40 19.71N, 73 30.41W
Tug Barge Pushing Sand on Starboard	Tug Barge Pushing Sand on Starbo...	40 19.63N, 73 30.31W

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APPENDIX G. PILOT STUDY: TREATMENT SESSION TWO ENTITIES

Objects (refreshed every 3 s.)

Label	Model	Position
AircraftCarrier CVN75	AircraftCarrier CVN75	40 28.87N, 73 54.03W
Amphib LHD1	Amphib LHD1	40 29.14N, 73 50.63W
Barge Dredge	Barge Dredge	40 30.40N, 73 57.17W
Barge Dredge 2	Barge Dredge	40 30.38N, 73 57.18W
Cargo Inland Blue	Cargo Inland Blue	40 27.47N, 73 41.16W
CG Cutter WHEC 2	CG Cutter WHEC	40 28.41N, 73 52.02W
CG47	CG47	40 27.00N, 73 48.63W
Containership Knud Maersk	Containership Knud Maersk	40 29.20N, 73 53.05W
Containership Knud Maersk RMD	Containership Knud Maersk	40 27.83N, 73 39.65W
Cruiser CG47	Cruiser CG47	40 28.36N, 73 52.89W
Ferry Turbo Cat Anchor Run	Ferry TurboCat	40 29.97N, 73 52.45W
Fishing Boat Trawling 16	Fishing Boat Trawling	40 25.90N, 73 45.47W
Fishing Boat Trawling 17	Fishing Boat Trawling	40 25.45N, 73 45.18W
Fishing Boat Trawling 18	Fishing Boat Trawling	40 25.72N, 73 45.65W
Fishing Boat Trawling 2	Fishing Boat Trawling	40 32.09N, 73 50.43W
Fishing Boat Trawling 4	Fishing Boat Trawling	40 30.23N, 73 56.12W
Fishing Boat Trawling 5	Fishing Boat Trawling	40 29.50N, 73 57.10W
Helicopter SeaHawk God Eye View	Helicopter SeaHawk	40 23.68N, 73 38.36W
PatrolBoat Police Boat	PatrolBoat Police Boat	40 29.00N, 73 50.94W
PatrolBoat Police Boat 2	PatrolBoat Police Boat	40 28.36N, 73 51.97W
PatrolBoat Police Boat 3	PatrolBoat Police Boat	40 28.83N, 73 50.41W
Pilot Vessel 2	Pilot Vessel	40 27.36N, 73 49.86W
PowerBoat Cabin Cruiser	PowerBoat Cabin Cruiser	40 25.99N, 73 45.73W
Sailboat Yacht 2	Sailboat Yacht	40 26.81N, 73 47.63W
Sailboat Yacht 3	Sailboat Yacht	40 26.76N, 73 48.75W
Smoke Float	Smoke Float	40 30.02N, 73 56.83W
Smoke Float 2	Smoke Float	40 28.93N, 73 53.41W
Smoke Float 3	Smoke Float	40 28.79N, 73 53.51W
Smoke Float 4	Smoke Float	40 28.86N, 73 53.46W
Tanker 132k	Tanker 132k	40 25.76N, 73 50.10W
Tanker 40k	Tanker 40k	40 29.22N, 73 55.11W
Tanker 80k	Tanker 80k	40 27.00N, 73 47.98W
Tanker Inland 2	Tanker Inland	40 29.50N, 73 55.82W
Tug 3	Tug Harbor Tractor 3	40 30.39N, 73 57.18W
Tug Barge Pushing Sand	Tug Barge Pushing Sand	40 30.77N, 73 59.12W
Tug Barge Pushing Sand on Starboard	Tug Barge Pushing Sand on Starbo...	40 31.40N, 74 00.81W
Tug Barge Pushing Sand on Starboar...	Tug Barge Pushing Sand on Starbo...	40 28.42N, 73 52.03W
Tug Barge Towing Sand Barge	Tug Barge Towing Sand Barge	40 28.02N, 73 51.27W

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APPENDIX H. PILOT STUDY: TREATMENT SESSION THREE ENTITIES

Objects (refreshed every 3 s.)

Label	Model	Position
AircraftCarrier CVN75	AircraftCarrier CVN75	40 29.85N, 73 56.20W
Barge Dredge 2	Barge Dredge	40 30.38N, 73 57.18W
Barge Dredge 3	Barge Dredge	40 24.87N, 73 32.30W
Barge Dredge 4	Barge Dredge	40 22.15N, 73 31.68W
Cargo Inland Blue	Cargo Inland Blue	40 27.16N, 73 46.27W
Cargo Vessel 25,000 dwt	Cargo Vessel 25,000 dwt	40 21.74N, 73 31.06W
Cargo Vessel 25,000 dwt 2	Cargo Vessel 25,000 dwt	40 20.93N, 73 32.03W
Cargo Vessel 25,000 dwt 3	Cargo Vessel 25,000 dwt	40 25.50N, 73 32.93W
CG Cutter WHEC 2	CG Cutter WHEC	40 28.41N, 73 52.02W
CG47	CG47	40 30.21N, 73 57.65W
Containership Knud Maersk RMD	Containership Knud Maersk	40 27.57N, 73 42.42W
Cruise Ship Grand Princess	Cruise Ship Grand Princess	40 22.19N, 73 15.62W
Cruise Ship Grand Princess 2	Cruise Ship Grand Princess	40 22.98N, 73 41.11W
Destroyer DDG79	Destroyer DDG79	40 20.18N, 73 34.03W
Ferry Turbo Cat Anchor Run	Ferry TurboCat	40 30.01N, 73 53.22W
Ferry TurboCat	Ferry TurboCat	40 20.54N, 73 34.70W
Fishing Boat Trawling	Fishing Boat Trawling	40 21.65N, 73 33.31W
Fishing Boat Trawling 11	Fishing Boat Trawling	40 25.90N, 73 49.23W
Fishing Boat Trawling 12	Fishing Boat Trawling	40 24.28N, 73 41.26W
Fishing Boat Trawling 13	Fishing Boat Trawling	40 24.63N, 73 40.84W
Fishing Boat Trawling 19	Fishing Boat Trawling	40 22.55N, 73 32.30W
Fishing Boat Trawling 4	Fishing Boat Trawling	40 30.20N, 73 56.03W
Fishing Boat Trawling 5	Fishing Boat Trawling	40 29.53N, 73 57.20W
Fishing Boat Trawling 8	Fishing Boat Trawling	40 20.96N, 73 40.98W
Fishing Boat Trawling 9	Fishing Boat Trawling	40 21.27N, 73 41.24W
Helicopter SeaHawk	Helicopter SeaHawk	40 20.54N, 73 34.30W
PatrolBoat Police Boat	PatrolBoat Police Boat	40 29.99N, 73 56.55W
PatrolBoat Police Boat 2	PatrolBoat Police Boat	40 28.35N, 73 52.02W
PatrolBoat Police Boat 3	PatrolBoat Police Boat	40 29.55N, 73 55.57W
Pilot Vessel	Pilot Vessel	40 22.37N, 73 34.63W
Pilot Vessel 2	Pilot Vessel	40 27.36N, 73 49.86W
Sailboat Yacht	Sailboat Yacht	40 21.19N, 73 32.49W
Smoke Float 2	Smoke Float	40 28.93N, 73 53.41W
Smoke Float 3	Smoke Float	40 28.79N, 73 53.51W
Smoke Float 4	Smoke Float	40 28.86N, 73 53.46W
Tanker 132k 2	Tanker 132k	40 23.40N, 73 40.97W
Tanker 40k	Tanker 40k	40 29.61N, 73 56.18W
Tanker 80k	Tanker 80k	40 27.65N, 73 40.53W
Tanker Inland 2	Tanker Inland	40 29.07N, 73 56.03W
Trawling	Fishing Boat Trawling	40 22.95N, 73 32.90W
trawling 2	Fishing Boat Trawling	40 22.01N, 73 33.97W
Tug 3	Tug Harbor Tractor 3	40 30.48N, 73 57.34W
Tug Barge Pushing Sand	Tug Barge Pushing Sand	40 22.85N, 73 30.09W
Tug Barge Pushing Sand 2	Tug Barge Pushing Sand	40 22.27N, 73 29.79W
Tug Barge Pushing Sand on Starboard	Tug Barge Pushing Sand on Starbo...	40 23.32N, 73 30.54W
Tug Barge Pushing Sand on Starboar...	Tug Barge Pushing Sand on Starbo...	40 28.52N, 73 52.43W
Tug Barge Towing Sand Barge	Tug Barge Towing Sand Barge	40 23.83N, 73 30.93W
Tug Barge Towing Sand Barge 2	Tug Barge Towing Sand Barge	40 24.24N, 73 31.61W

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APPENDIX I. EXPERIMENTAL STUDY: TREATMENT SESSION ENTITIES

Objects (refreshed every 3 s.)

Label	Model	Position
AircraftCarrier CVN75	AircraftCarrier CVN75	40 29.33N, 73 54.81W
alpha Amphib LPD4	Amphib LPD4	40 15.66N, 72 44.63W
Alpha Cruise Ship Grand Princess 3	Cruise Ship Grand Princess	40 10.14N, 72 40.81W
alpha DDG51 (place students here ru...	DDG51	40 10.88N, 72 43.05W
alpha Ferry TurboCat 2	Ferry TurboCat	40 11.06N, 72 45.30W
alpha Helicopter SeaHawk (place stu...	Helicopter SeaHawk	40 18.38N, 73 27.89W
Alpha PowerBoat Cabin Cruiser	PowerBoat Cabin Cruiser	40 12.30N, 72 42.33W
Alpha Tanker 40k 2	Tanker 40k	40 14.16N, 72 47.83W
Alpha Tug Barge Pushing Sand 4	Tug Barge Pushing Sand	40 10.54N, 72 44.94W
alpha Tug Barge Pushing Sand on St...	Tug Barge Pushing Sand on Starbo...	40 13.05N, 72 48.95W
Barge Dredge 2	Barge Dredge	40 29.61N, 73 55.16W
Barge Dredge 4	Barge Dredge	40 21.11N, 73 33.50W
Cargo Inland Blue	Cargo Inland Blue	40 27.00N, 73 49.64W
Cargo Vessel 25,000 dwt	Cargo Vessel 25,000 dwt	40 20.90N, 73 33.17W
Cargo Vessel 25,000 dwt 2	Cargo Vessel 25,000 dwt	40 19.34N, 73 30.03W
Cargo Vessel 25,000 dwt 3	Cargo Vessel 25,000 dwt	40 24.25N, 73 37.36W
CG Cutter WHEC 2	CG Cutter WHEC	40 28.41N, 73 52.02W
Containership Knud Maersk RMD	Containership Knud Maersk	40 27.55N, 73 47.34W
Cruise Ship Grand Princess 2	Cruise Ship Grand Princess	40 23.43N, 73 42.06W
Destroyer DDG79	Destroyer DDG79	40 18.67N, 73 28.53W
Ferry Turbo Cat Anchor Run	Ferry TurboCat	40 29.24N, 73 56.23W
Ferry TurboCat	Ferry TurboCat	40 18.88N, 73 29.01W
Fishing Boat Trawling	Fishing Boat Trawling	40 19.72N, 73 30.87W
Fishing Boat Trawling 11	Fishing Boat Trawling	40 26.11N, 73 49.23W
Fishing Boat Trawling 12	Fishing Boat Trawling	40 25.90N, 73 48.81W
Fishing Boat Trawling 13	Fishing Boat Trawling	40 25.90N, 73 48.26W
Fishing Boat Trawling 19	Fishing Boat Trawling	40 21.33N, 73 33.86W
Fishing Boat Trawling 4	Fishing Boat Trawling	40 30.13N, 73 55.86W
Fishing Boat Trawling 5	Fishing Boat Trawling	40 29.67N, 73 57.60W
Helicopter SeaHawk run 3 view	Helicopter SeaHawk	40 29.97N, 73 56.68W
PatrolBoat Police Boat	PatrolBoat Police Boat	40 29.44N, 73 55.15W
PatrolBoat Police Boat 2	PatrolBoat Police Boat	40 28.35N, 73 52.02W
PatrolBoat Police Boat 3	PatrolBoat Police Boat	40 29.18N, 73 54.50W
Pilot Vessel	Pilot Vessel	40 20.07N, 73 31.65W
Pilot Vessel 2	Pilot Vessel	40 27.36N, 73 49.86W
PowerBoat Cabin Cruiser	PowerBoat Cabin Cruiser	40 28.57N, 73 56.73W
Sailboat Yacht	Sailboat Yacht	40 19.54N, 73 30.45W
Sailboat Yacht 2	Sailboat Yacht	40 26.55N, 73 44.57W
Sailboat Yacht 3	Sailboat Yacht	40 30.32N, 73 54.76W
Smoke Float	Smoke Float	40 19.09N, 73 29.51W
Smoke Float 2	Smoke Float	40 28.93N, 73 53.41W
Smoke Float 3	Smoke Float	40 28.79N, 73 53.51W
Smoke Float 4	Smoke Float	40 28.86N, 73 53.46W
Smoke Float 5	Smoke Float	40 20.47N, 73 32.28W
Smoke Float 6	Smoke Float	40 21.95N, 73 34.88W
Smoke Float 7	Smoke Float	40 24.04N, 73 37.18W
Tanker 132k 2	Tanker 132k	40 25.44N, 73 49.14W
Tanker 40k	Tanker 40k	40 29.00N, 73 54.57W
Tanker 00k	Tanker 00k	40 27.51N, 73 44.55W
Tanker Inland 2	Tanker Inland	40 29.62N, 73 56.18W
Trawling	Fishing Boat Trawling	40 21.53N, 73 34.21W
trawling 2	Fishing Boat Trawling	40 19.88N, 73 31.22W
Tug 3	Tug Harbor Tractor 3	40 29.64N, 73 55.21W
Tug Barge Pushing Sand	Tug Barge Pushing Sand	40 23.04N, 73 36.07W
Tug Barge Pushing Sand 2	Tug Barge Pushing Sand	40 22.36N, 73 35.34W
Tug Barge Pushing Sand on Starboard	Tug Barge Pushing Sand on Starbo...	40 23.37N, 73 36.42W
Tug Barge Pushing Sand on Starboar...	Tug Barge Pushing Sand on Starbo...	40 29.88N, 73 56.14W
Tug Barge Towing Sand Barge	Tug Barge Towing Sand Barge	40 23.70N, 73 36.77W
Tug Barge Towing Sand Barge 2	Tug Barge Towing Sand Barge	40 22.71N, 73 35.71W

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APPENDIX J. RULES OF THE ROAD—STUDY LOG

Rules of the Road –Study Log

Participant ID: _____

Please annotate the times you studied for Rules of the Road. You can annotate this by **shading in** or marking an **X** in the box. The study log is to account for any additional time you spend outside of normal working hours and this study to prepare for the SWOSCOLCOM RoR test while participating in this study.

Times	Day of Session1	Day of Session 2	Day of Session 3	Day of Session 4
0600-0630				
0630-0700				
0700-0730				
0730-0800				
0800-0830				
0830-0900				
0900-0930				
0930-1000				
1000-1030				
1030-1100				
1130-1200				
1230-1300				
1300-1330				
1430-1500				
1530-1600				
1600-1630				
1630-1700				
1730-1800				
1800-1830				
1830-1900				
1930-1930				
1930-2000				
2000-2030				
2030-2100				
2130-2200				
2200-2230				
2230-2300				
2300-2330				
2330-2400				

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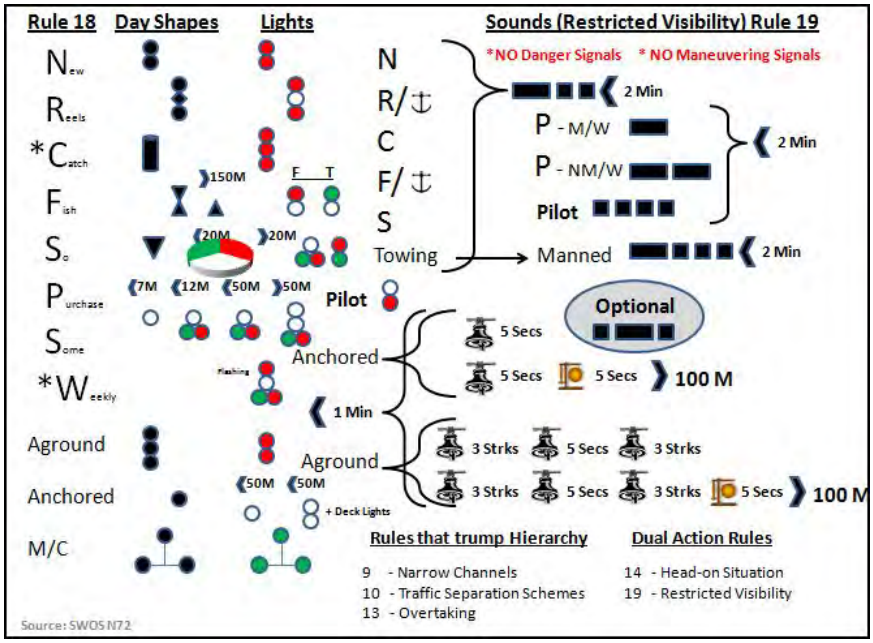
APPENDIX K. RULES OF THE ROAD KNEE BOARD



Rule 34 – Sound and Light Signals

•Int'l
1 Short – "I am altering my course to STBD."
2 Short – "I am altering my course to PORT."
3 Short – "I am operating astern propulsion."

•Inland
1 Short – "I intend to LEAVE you on MY PORT side."
2 Short – "I intend to LEAVE you on MY STBD side."
3 Short – "I am operating astern propulsion."

•Agreement Response
1 or 2 Short if in agreement.
If in doubt, you SHALL sound the danger signal.
*Agreement by BtB negates necessity of sound signals, but you may do so.

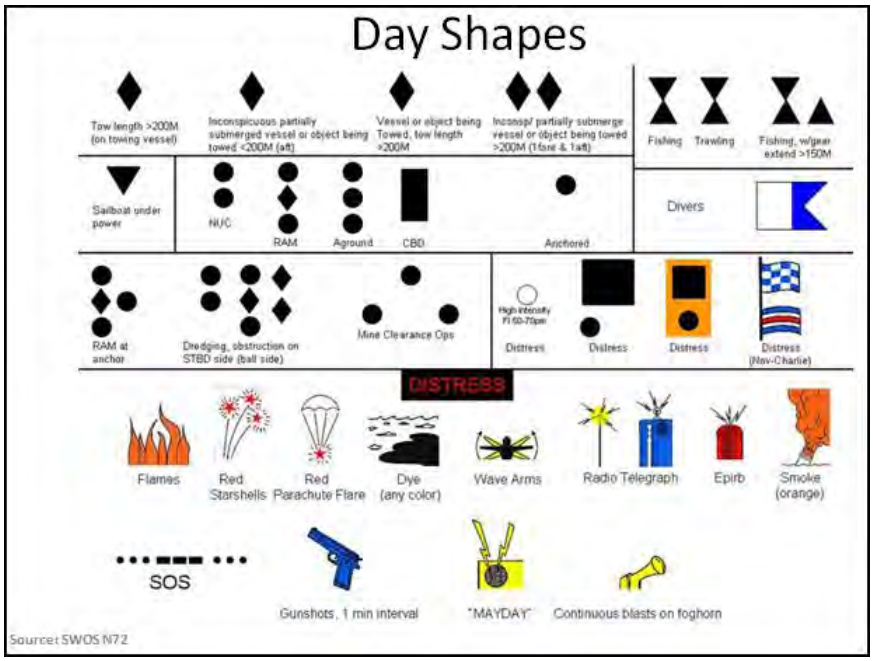
•Narrow Channel
2 Prolonged, 1 Short – "I intend to OVERTAKE you on YOUR STBD side."
2 Prolonged, 2 Short – "I intend to OVERTAKE you on YOUR PORT side."

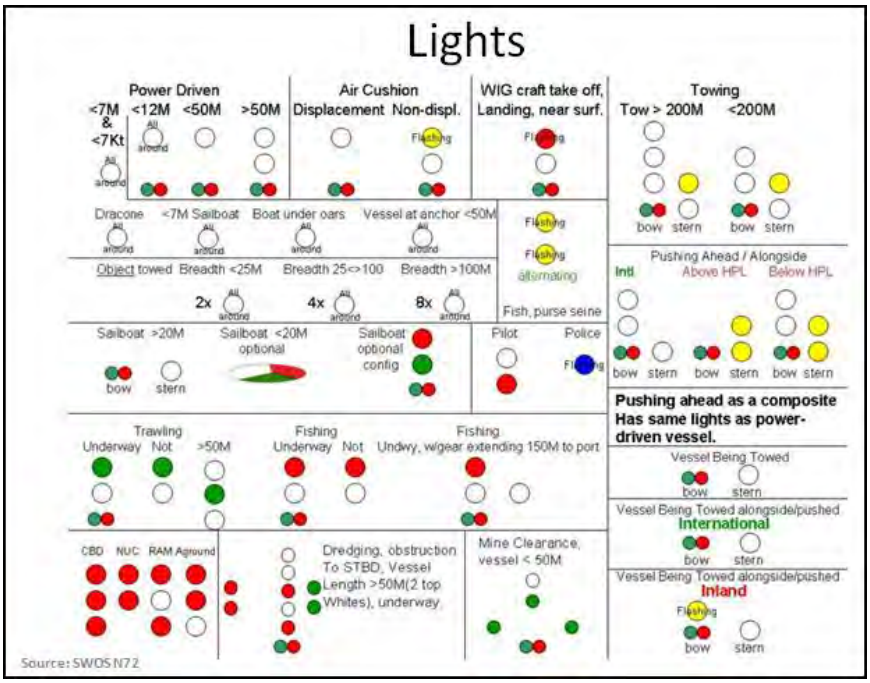
•Agreement Response
1 Prolonged, 1 Short, 1 Prolonged, 1 Short if in agreement.
If in doubt, you SHALL sound the danger signal.

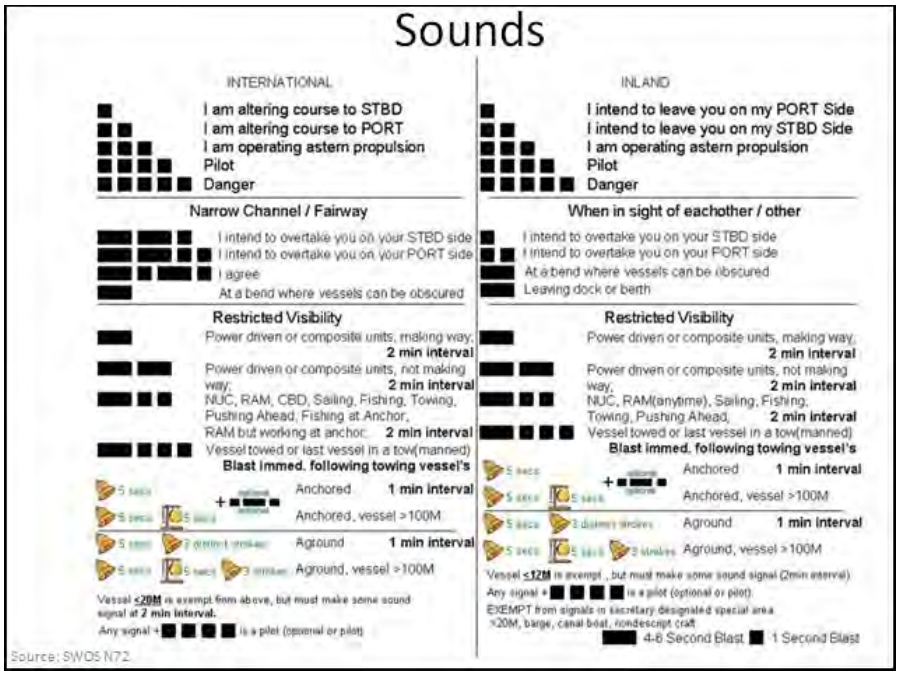
•Nearing A Bend
1 Prolonged

•Agreement Response
1 Prolonged, by approaching vessel in earshot

Source: SWOS N72


Day Shapes
Tow length >200M (on towing vessel)
Inconspicuous partially submerged vessel or object being towed <200M (aft)
Vessel or object being Towed, tow length >200M
Inconsp/ partially submerge vessel or object being towed >200M (1fore & 1aft)
Fishing
Trawling
Fishing, w/gear extend >150M
Sailboat under power
NUC
RAM
Aground
CBD
Anchored
Divers
RAM at anchor
Dredging, obstruction on STBD side (ball side)
Mine Clearance Ops
High intensity Fl 50-70pm
Distress
Distress
Distress
Distress (Nov-Charlie)
DISTRESS
Flames
Red Starshells
Red Parachute Flare
Dye (any color)
Wave Arms
Radio Telegraph
Epirb
Smoke (orange)
SOS
Gunshots, 1 min interval
"MAYDAY"
Continuous blasts on foghorn
Source: SWOS N72


Lights
Power Driven
<7M & <7Kt
<12M
<50M
>50M
Air Cushion Displacement
Non-displ.
WIG craft take off, Landing, near surf.
Towing
Tow > 200M
<200M
bow
stern
Dracone
<7M Sailboat
Boat under oars
Vessel at anchor <50M
Object towed
Breadth <25M
Breadth 25<>100
Breadth >100M
2x
4x
8x
Fish, purse seine
Sailboat >20M
Sailboat <20M optional
Sailboat optional config
Pilot
Police
Pushing Ahead / Alongside
Intl
Above HPL
Below HPL
Pushing ahead as a composite Has same lights as power-driven vessel.
Trawling
Underway
Not
>50M
Fishing
Underway
Not
Fishing
Undwy, w/gear extending 150M to port
Vessel Being Towed
Vessel Being Towed alongside/pushed
International
Vessel Being Towed alongside/pushed
Inland
CBD
NUC
RAM
Aground
Dredging, obstruction To STBD, Vessel Length >50M(2 top Whites), underway
Mine Clearance, vessel < 50M
Source: SWOS N72


Sounds
INTERNATIONAL
I am altering course to STBD
I am altering course to PORT
I am operating astern propulsion
Pilot
Danger
Narrow Channel / Fairway
I intend to overtake you on your STBD side
I intend to overtake you on your PORT side
I agree
At a bend where vessels can be obscured
Restricted Visibility
Power driven or composite units, making way; 2 min interval
Power driven or composite units, not making way; 2 min interval
NUC, RAM, CBD, Sailing, Fishing, Towing, Pushing Ahead, Fishing at Anchor, RAM but working at anchor; 2 min interval
Vessel towed or last vessel in a tow(manned)
Blast immed. following towing vessel's
Anchored 1 min interval
Anchored, vessel >100M
Aground 1 min interval
Aground, vessel >100M
Vessel <20M is exempt from above, but must make some sound signal at 2 min interval.
Any signal + is a pilot (optional or pilot)
INLAND
I intend to leave you on my PORT Side
I intend to leave you on my STBD Side
I am operating astern propulsion
Pilot
Danger
When in sight of eachother / other
I intend to overtake you on your STBD side
I intend to overtake you on your PORT side
At a bend where vessels can be obscured
Leaving dock or berth
Restricted Visibility
Power driven or composite units, making way, 2 min interval
Power driven or composite units, not making way; 2 min interval
NUC, RAM(anytime), Sailing, Fishing, Towing, Pushing Ahead, 2 min interval
Vessel towed or last vessel in a tow(manned)
Blast immed. following towing vessel's
Anchored 1 min interval
Anchored, vessel >100M
Aground 1 min interval
Aground, vessel >100M
Vessel <12M is exempt , but must make some sound signal (2min interval)
Any signal + is a pilot (optional or pilot)
EXEMPT from signals in secretary designated special area
<20M, barge, canal boat, nondescript craft
4-6 Second Blast
1 Second Blast
Source: SWOS N72.

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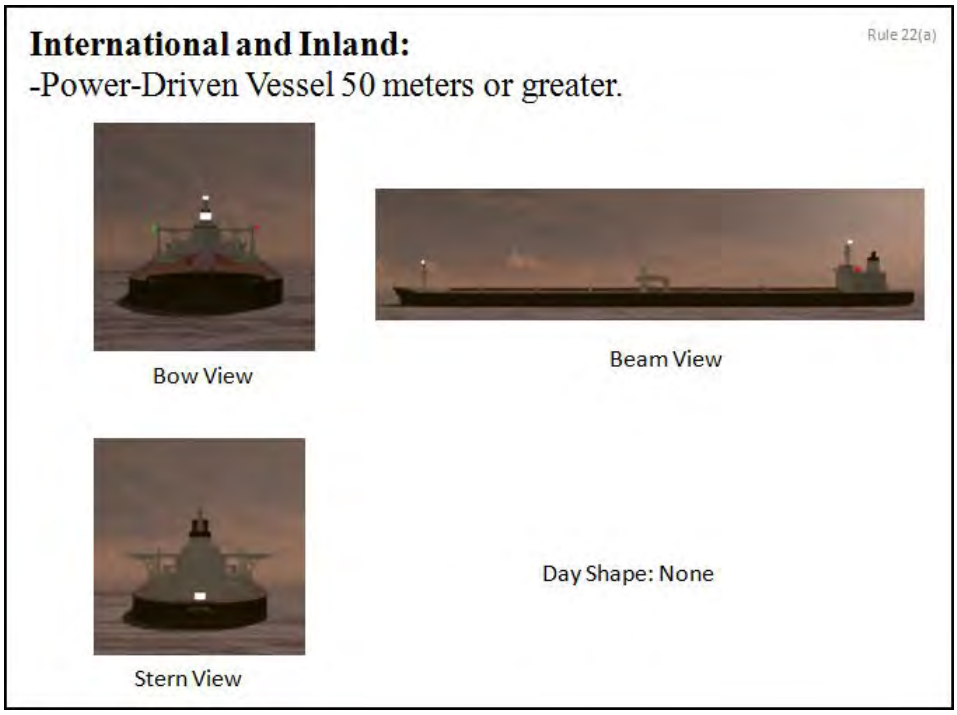
APPENDIX L. SUBMARINE ON BOARD TRAINING: SCREEN SHOTS FROM RULES OF THE ROAD LESSON



Rule 23(b)

International and Inland:

-Air-Cushion Vessel operating in non-displacement (hovering) mode.

Bow View

Beam View

Stern View

Day Shape: None

Rule 23(c)

Wing-In-Ground (WIG) Craft (International)

A WIG craft only when taking off, landing and in flight near the surface shall , in addition to the lights prescribed in Rule 23(a), exhibit a high intensity all-round flashing red light.

Rule 31

Seaplane (Inland)

International and Inland: Rule 23(c)

-Power-Driven Vessel less than 12 meters.

Bow View

Beam View

Stern View

Day Shape: None

International and Inland: Rule 24(a)

-Towing Vessel less than 50 meters

-Tow is greater than 200 Meters in length

Bow View

Beam View

Stern View

Day Shape:
Diamond

International and Inland:

Rule 24(a)

-Towing Vessel less than 50 meters

-Tow is less than or equal 200 Meters in length

Overall View

Stern View

Day Shape: None

International and Inland:

Rule 24(b)

-Composite Vessel less than 50 meters

Bow View

Beam View

Stern View

Day Shape: None

International and Inland:

Rule 24(b)

-Composite Vessel 50 meters or greater

Bow View

Beam View

Stern View

Day Shape: None

International:

Rule 24(c)

-Towing Alongside

Bow View

Beam View

Stern View

Day Shape: None

Inland:
-Towing Alongside

Rule 24(c)

Bow View

Beam View

Stern View

Day Shape: None

International:
-Pushing Ahead

Rule 24(c)

Bow View

Beam View

Stern View

Day Shape: None

Inland:

Rule 24(c)

-Pushing Ahead

Bow View

Beam View

Stern View

Day Shape: None

International:

Rule 24(d)

-Power-Driven Vessel towing, 50 meters or greater.

Bow View

Beam View

Stern View

Day Shape: None

Inland: Rule 24(d)

-Power-Driven Vessel Towing, 50 meters or greater.

Bow View

Beam View

Stern View

Day Shape: None

International and Inland: Rule 24(e)

-Vessel or Object being towed

Bow View

Beam View

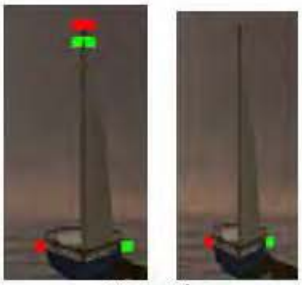
Stern View

Day Shape:
Diamond when length of
tow exceeds 200 meters

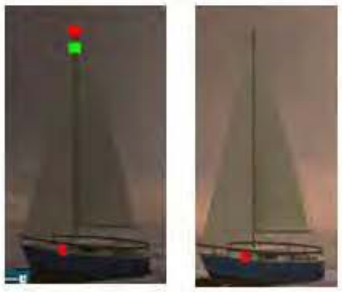
International and Inland:

Rule 25(a) and (c)

-Sailing Vessel any length.



Bow View



Beam View

Stern View

Day Shape:
Apex downwards, when under sail and power. Not required if less than 12 meters

International and Inland:

Rule 25(b)

-Sailing Vessel less than 20 meters option.

Bow View

Beam View

Stern View

Day Shape:
Apex downwards, when under sail and power. Not required if less than 12 meters

International and Inland: Rule 25(e)

-Sailing Vessel under sail and power.

Bow View

Beam View

Stern View

Day Shape:
Apex downwards, when under sail and power. Not required if less than 12 meters

International and Inland: Rule 26(b)

-Fishing Vessel less than 50 meters (Trawling), Not making way

Bow View

Beam View

Stern View

Day Shape:
Apex Together

Rule 26(c)

International and Inland:

-Fishing Vessel less than 50 meters (Not trawling). Making way

Bow View

Beam View

Stern View

Day Shape:
Apex together

If gear extends more than 150 meters horizontally from vessel, a cone apex upwards in direction of gear

Rule 26(c)

International and Inland:

-Fishing Vessel less than 50 meters (Not trawling). Not making way

Bow View

Beam View

Stern View

Day Shape:
Apex together

If gear extends more than 150 meters horizontally from vessel, a cone apex upwards in direction of gear

International and Inland:

Rule 26(c)

-Fishing Vessel less than 50 meters (Not trawling). Gear extended more than 150 meters. Making way

Bow View

Beam View

Stern View

Day Shape:
Apex together

If gear extends more than 150 meters horizontally from vessel, all around white light or a cone apex upwards in direction of gear

International and Inland:

Rule 26(c)

-Fishing Vessel less than 50 meters (Not trawling). Gear extended more than 150 meters. Not making way.

Bow View

Beam View

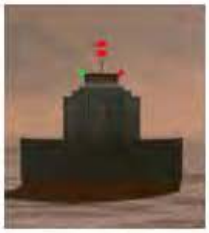
Stern View

Day Shape:
Apex together

If gear extends more than 150 meters horizontally from vessel, all around white light or a cone apex upwards in direction of gear

International and Inland:
-Not Under Command, Making Way

Rule 27(a)



Bow View

Beam View

Stern View

Day Shape:
Ball over Ball

International and Inland:
-Not Under Command, Not Making Way

Rule 27(a)

Bow View

Beam View

Stern View

Day Shape:
Ball over Ball

International and Inland:

Rule 27(b)

-Restricted In Ability to Maneuver. Making Way

Bow View

Beam View

Stern View

Day Shape:
Diamond, Ball, Diamond

International and Inland:

Rule 27(b)

-Restricted In Ability to Maneuver. Not Making Way

Bow View

Beam View

Stern View

Day Shape:
Diamond, Ball, Diamond

Rule 27(c)

International and Inland:

-Towing Vessel (Inland) or Power-Driven Vessel engaged in towing (International) which severely restricts the towing vessel and her tow.

Bow View

Beam View

Stern View

Day Shape:
Ball, Diamond, Ball

Rule 27(d)

International and Inland:

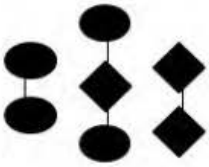
-Dredging or Underwater Operations, Making Way

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball (obstr. side)
Ball, Diamond, Ball
Diamond, Diamond (clear side)



International and Inland:

Rule 27(d)

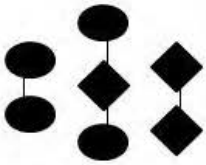
-Dredging or Underwater Operations, Not Making Way.

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball (obstr. side)
Ball, Diamond, Ball
Diamond, Diamond (clear side)



International and Inland:

Rule 27(e)

-Vessel engaged in Diving Operations

Bow View

Beam View

Stern View

Day Shape:
Code flag "A"

International and Inland:

Rule 27(f)

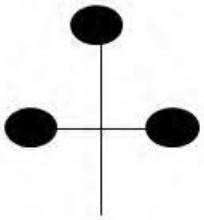
-Mine clearance operations less than 50 meters.

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball, Ball



International and Inland:

Rule 27(f)

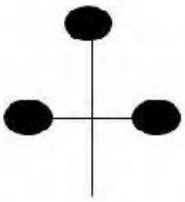
-Mine clearance operations 50 meters or greater.

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball, Ball



International:

Rule 28

-Constrained by Draft less than 50 meters

Bow View

Beam View

Stern View

Day Shape:
Cylinder

International:

Rule 28

-Constrained by Draft 50 meters or greater

Bow View

Beam View

Stern View

Day Shape:
Cylinder

International and Inland:
-Pilot Vessel. Making Way

Rule 29(a)

Bow View

Beam View

Stern View

Day Shape:

H-Hotel

International and Inland:
-Pilot Vessel. At anchor

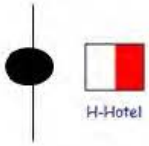
Rule 29(a)

Bow View

Beam View

Stern View

Day Shape:



H-Hotel

International and Inland:

Rule 30(a) and (c)

-Anchored Vessel 50 meters or greater. Vessels 100 meters or more shall use available working lights to illuminate decks.

Bow View

Beam View

Stern View

Day Shape:
Ball

International and Inland:

Rule 30(d)

-Aground Vessel less than 50 meters

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball, Ball

International and Inland:

Rule 30(d)

-Aground Vessel 50 meters or greater

Bow View

Beam View

Stern View

Day Shape:
Ball, Ball, Ball

International and Inland:

Rule 30(f)

-Anchored Vessel less than 12 meters

Bow View

Beam View

Stern View

Day Shape:
Ball

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APPENDIX M. NAVAL POSTGRADUATE SCHOOL CONSENT TO PARTICIPATE IN RESEARCH

Naval Postgraduate School
Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled *Immersive Rules of the Road: Immersion of Simulation and Traditional Classroom Lecture for Rules of the Road Training*. The purpose of this study is to determine if using simulation technology will increase a student's ability to apply International Regulations for Preventing Collisions at Sea 1972 (72 COLREGS) and Inland Navigation Rules knowledge.

Procedures. The study will require up to 96 volunteers. Each volunteer will be asked to complete a demographic questionnaire, pre and post-test, post-study questionnaire, and study log. Participants will be randomly separated into two groups, treatment and control group. Randomization of participants will be conducted utilizing a random number generator from www.randomizer.com/htm.

The treatment group will utilize the Full Mission Bridge (FMB) simulator and will be limited to these components of FMB: (1) ready 360 degree display, (2) Radar, (3) Voyage Management System (VMS), (4) binoculars, (5) bridge-to-bridge radio, and (6) centerline pelorus. The treatment group will be placed in teams of no more than 6 to operate the FMB simulator. The researcher will control the ship's maneuvering with the assistance of the team utilizing the provided commands from SWOS. In the first session, a demographic survey and pre-test will be completed. In addition, each team will proceed from anchor to the beginning of a traffic separation scheme in NYC harbor. In the second session, each team will enter the TSS in order to pull into port. Enroute to NYC, the team will be rerouted to for another mission. In the 3rd session, each team will be in ocean open and this will conclude the treatment session. During each session, participants will answer questions about that scene and all questions will be reviewed together after each session. In the 4th and final session, all participants will complete a post-test, post-survey, and submit study log. The study log is to account for any additional time you spend outside of normal working hours and the study to prepare for the SWOSCOL/COM RoR test while participating in this study.

The control group will utilize a classroom to conduct their study sessions and it will reflect the material being presented to the treatment group. In the 1st session, a demographic survey and pre-test will be completed. In addition, the participant will utilize the remaining time to study RoR with presented material. In the 2nd and 3rd session, the participant will continue studying on an individual basis or join a group if one or more are formed and complete post-survey in 3rd session. The material presented to the control group will be Navigation Rule for International and Inland Waters book, power point lectures from SWOS, and visual aids. A researcher will be present at these sessions. In the 4th and final session, all participants will complete a post-test and submit study log.

The study will not interfere with the ASAT course. There is no cost to participate in this research study. Individual data will only be available to the researchers and your results will be available to you at the end of the research study. Each session will last approximately 1 hour in length and will take place after normal working hours between 1800-2200. There will be 4 one-hour blocks designated between 1800-2200 for the treatment group. The control group will conduct their one-hour session from 1800-1900.

Location. The experiment will take place at SWOS NEWPORT. If you are in the treatment group, you will report to FMB located on the 1st deck of Memorial Hall. If you are in the control group, you will report to room 257 (OMMS NG-Lab) in Weakly Hall on the second deck.

Cost. There is no cost to participate in this research study.

Version #
Date:

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. Participants must be from the ASAT course, have 20/20 or correctable to 20/20 vision, and not be color blind. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. There is no risk to academic standing if they do or do not participate, or choose not to complete the study. The alternative to participating in the research is to not participate in the research.

Potential Risks and Discomforts. The potential risks of participating in this study are mismanagement of data and possible simulator motion sickness. Risks will be mitigated by securing collected data in a secure cabinet located at SWOS and only the researchers have access to this cabinet. The FMB simulator will not have any sea state. Participants experiencing motion sickness will be immediately removed from the study.

Anticipated Benefits. If the RoR simulation training used in this study positively effects the participants post-tests when comparing to pre-test and that the participates suggest this platform of training is beneficial in learning RoR, then we can suggest that the U.S. Navy utilize RoR software to assist in training enlisted personnel and officers in RoR. This will only support the need for increasing simulation technology in curriculums that have been traditionally instructed in a classroom environment and will only aid in teaching the current and future generation of enlisted personnel and officers. You will not directly benefit from your participation in this research.

Compensation for Participation. No tangible compensation will be given.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. Collected data will be secured in a secure cabinet located at SWOS and only the researchers have access to this cabinet. Demographic information collected will not have any information that can link the participant to the study (i.e. hull name of current ship they are serving, port, or ship type). All collected data will be sent via priority shipping to NPS IRB administrator for record keeping.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study please contact the Principal Investigator, CDR Joseph Sullivan, USN, 831-656-7582, sullivan@nps.edu . Questions about your rights as a research subject or any other concerns may be addressed to the Navy Postgraduate School IRB Chair, CAPT John Schmidt, USN, 831-656-3864, jkschmid@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

_____ _____

Participant's Signature Date

_____ _____

Researcher's Signature Date

Version #
Date:

APPENDIX N. STANDARD COMMANDS

STANDARD COMMANDS

NOTE: The standard commands listed are for the researchers and are not intended to be a standard for the Fleet.

All commands should have:

Ahead / Back / Stop / 1/3, 2/3, Standard, Full, Flank and ability to work port and starboard engines individually.

Ex.

Conning Officer's Command (Team)	"All engines ahead _____ for _____ knots."
Helmsman's Response (Researcher)	"All engines ahead _____ for _____ knots aye aye, sir or ma'am."
Helmsman's Response (Researcher)	"All engines are ahead _____ for _____ knots sir or ma'am."
Conning Officer's Response (Team)	"Very Well."

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APPENDIX O. CONTROL AND EXPERIMENTAL GROUP: RULES OF THE ROAD INDIVIDUAL TEST QUESTION COMPARISON

Individual rules on the control group RoR practice test whose score was less than a 90 percent cumulatively were compared with the experimental groups mean score conducting a t-test. The hypothesized value was provided from the *Test Analysis Report* (Appendix D) produced by the SWOS Newport Perception database (Zieroth, 2012).

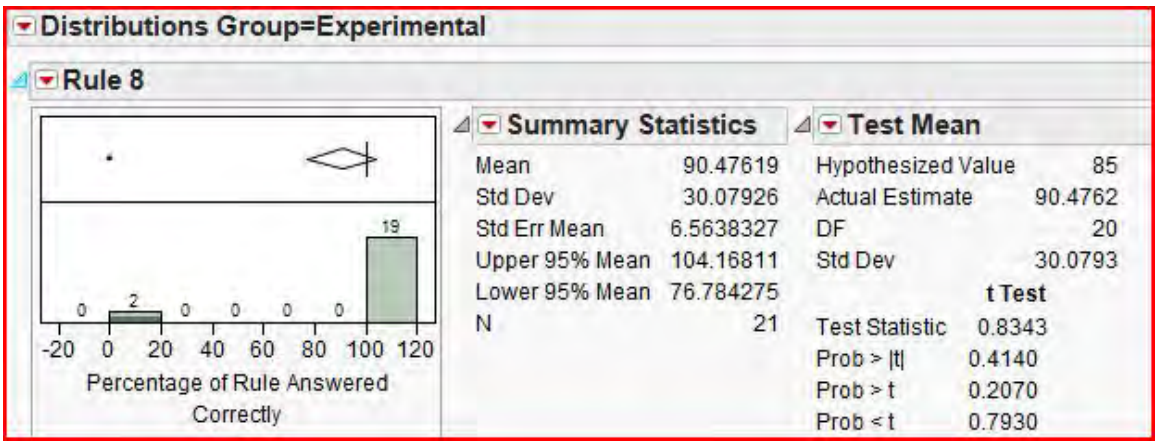

Figure 50. Experimental and Control Group Comparison of Rule 8

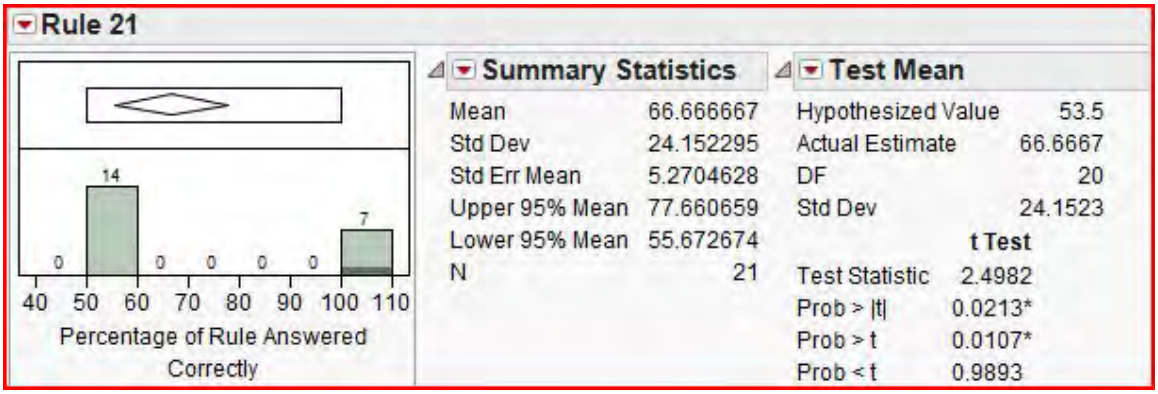

Figure 51. Experimental and Control Group Comparison of Rule 21

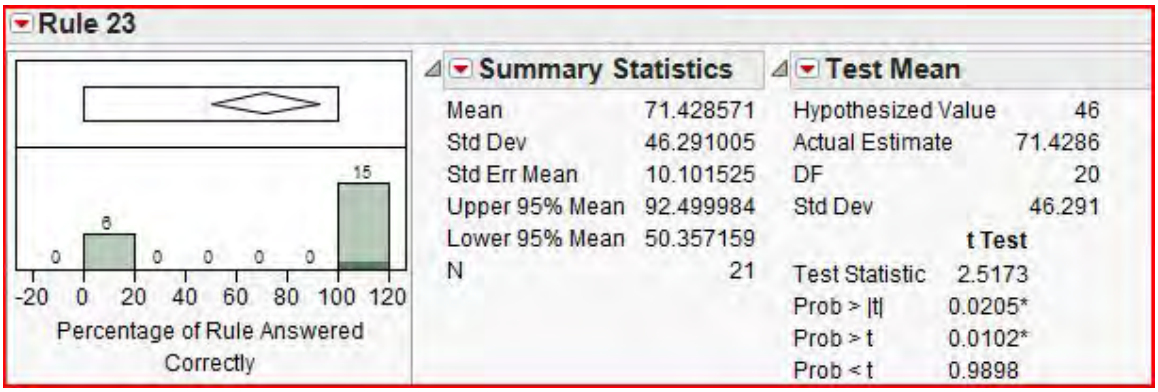

Figure 52. Experimental and Control Group Comparison of Rule 23

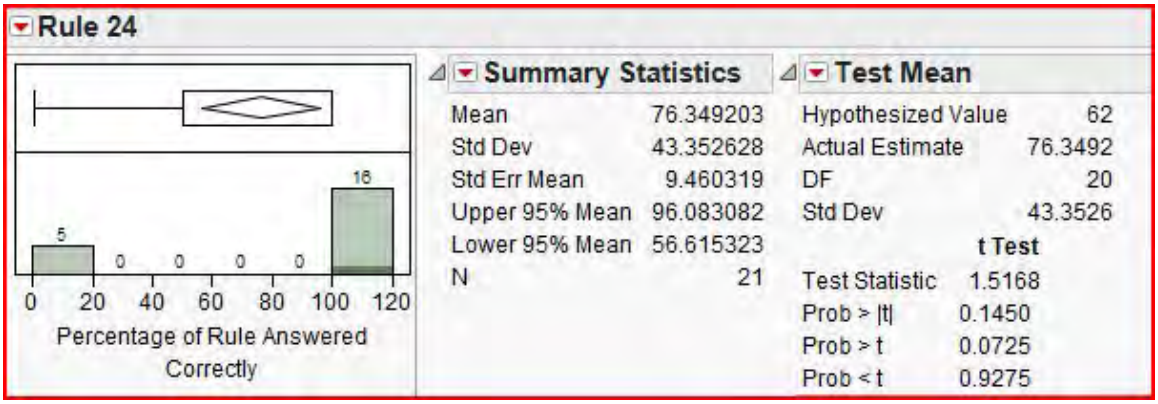

Figure 53. Experimental and Control Group Comparison of Rule 24

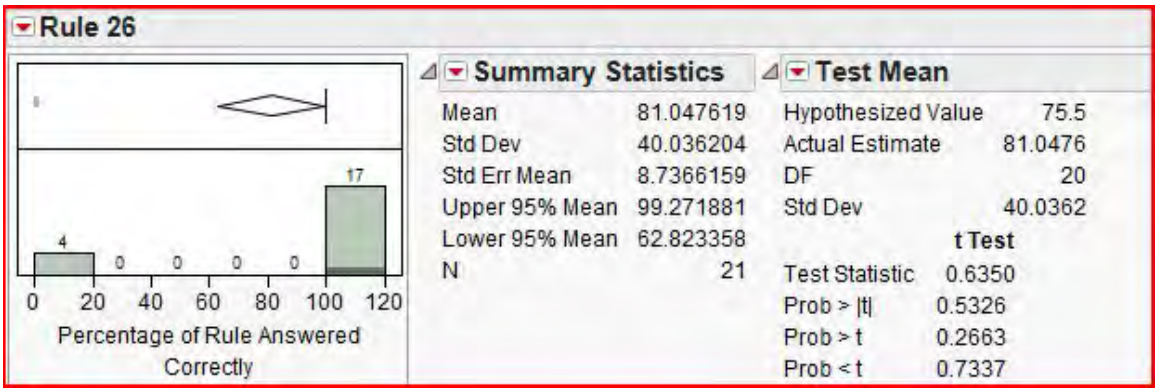

Figure 54. Experimental and Control Group Comparison of Rule 25

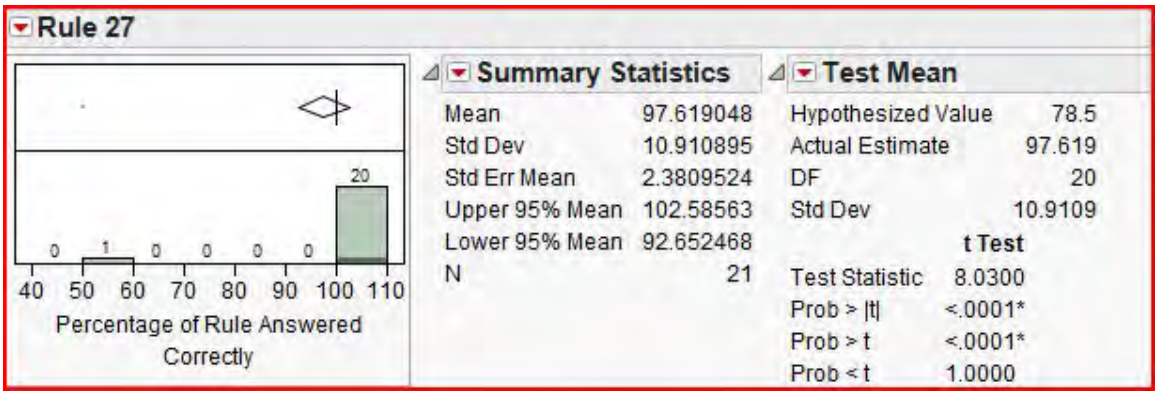

Figure 55. Experimental and Control Group Comparison of Rule 26

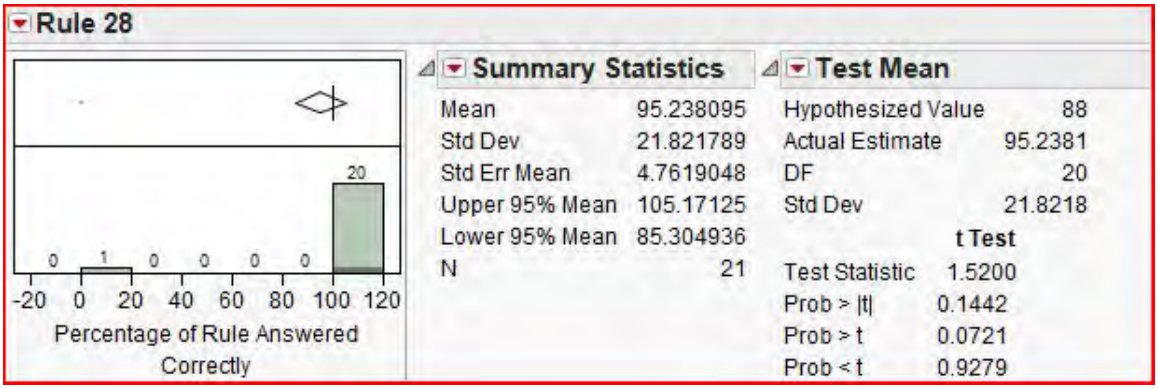

Figure 56. Experimental and Control Group Comparison of Rule 28

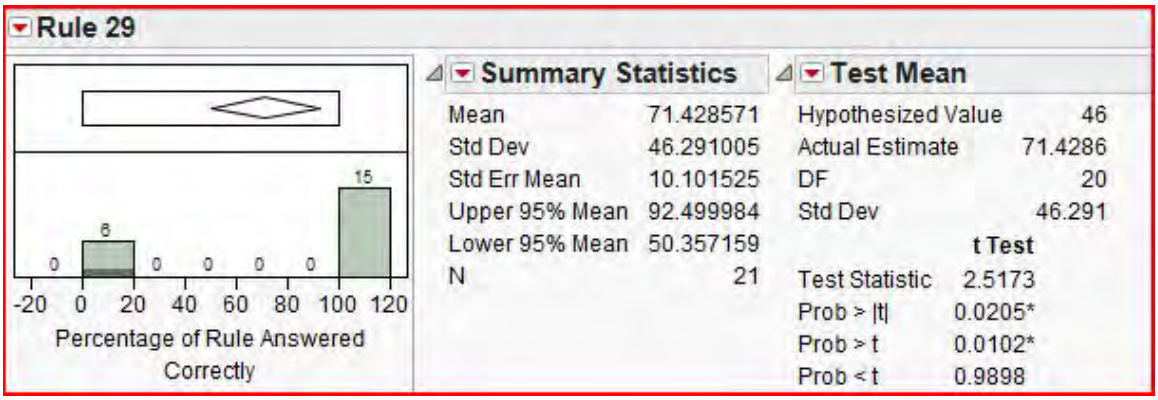

Figure 57. Experimental and Control Group Comparison of Rule 29

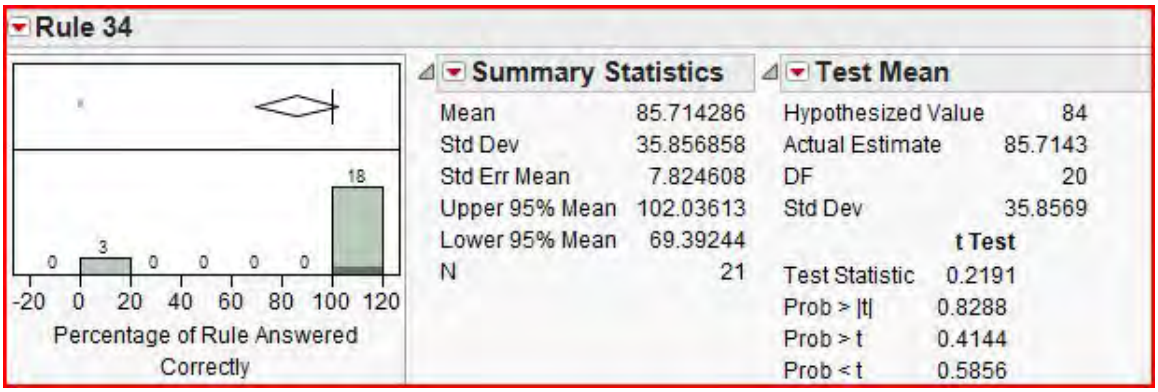

Figure 58. Experimental and Control Group Comparison of Rule 34

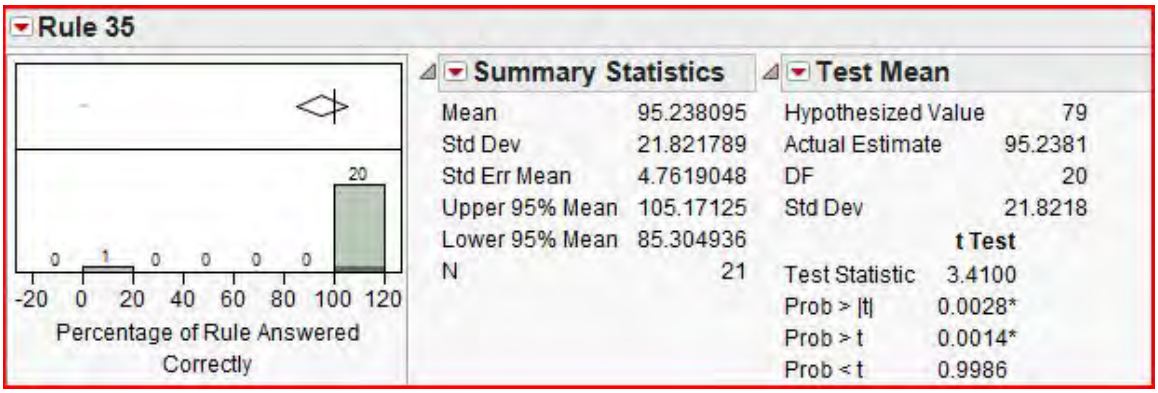

Figure 59. Experimental and Control Group Comparison of Rule 35

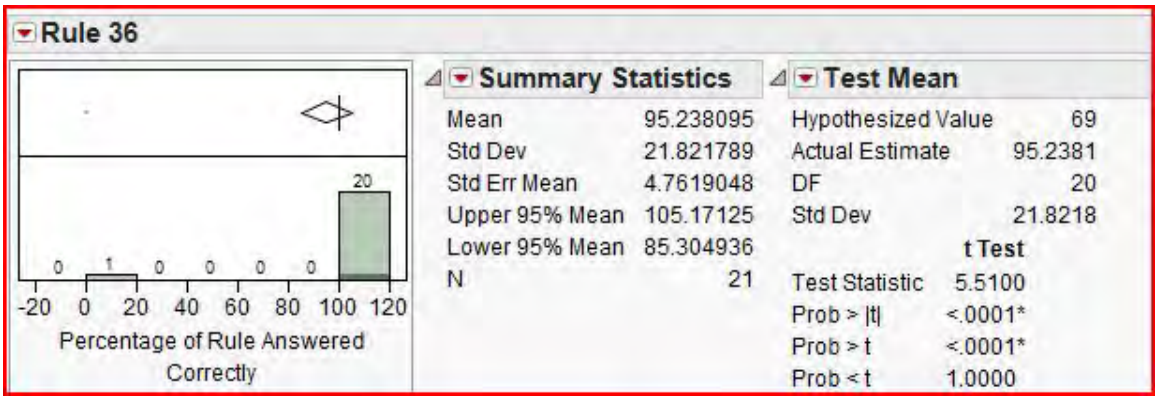

Figure 60. Experimental and Control Group Comparison of Rule 36

APPENDIX P. SUPPORT OF STUDENT RESEARCH STUDY

DEPARTMENT OF THE NAVY
SURFACE WARFARE OFFICERS SCHOOL COMMAND
446 CUSHING ROAD
NEWPORT RHODE ISLAND 02841-1208
HTTP://WWW.SWOS.NAVY.MIL/

IN REPLY REFER TO:
1000
Ser N72/191
6 June 12

From: Commanding Officer, Surface Warfare Officers School Command
To: President, Naval Postgraduate School

Subj: SUPPORT OF STUDENT RESEARCH STUDY

1. The purpose of this letter is to provide the Naval Postgraduate School (NPS) Institutional Review Board (IRB) written permission for a MOVES curriculum Masters student thesis research study titled "Immersion of Simulation and Traditional Classroom Lecture for Rules of the Road Training."

2. LTs John Weaver and Ethan Reber are authorized to conduct research and analyze Rules of the Road data in the Fleet Training Directorate, Surface Warfare Officers School Command facilities, with student and instructor volunteers from the Advanced Shiphandling and Tactics course. This research will be conducted after normal working hours and on a not to interfere basis.

3. After being approved by NPS IRB, LTs Weaver and Reber are authorized to conduct their first research study session and are conditionally approved for follow-on sessions. Follow-on sessions will be terminated if students or instructors submit negative feedback to the Director, Fleet Training related to researcher conduct or implementation of the research study.

M. D. DVIOS
By Direction

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